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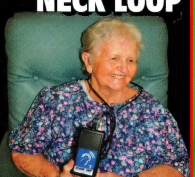

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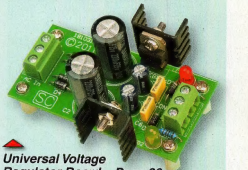

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Publisher's Letter

Power factor correction gizmos do not save power

The first week of February caused a certain amount of excitement in the SILICON CHIP offices. This was triggered off by the Seven Network's *Today Tonight* feature item on the Earthwise Power Saver on Monday January 31st. This was immediately followed by a number of emails from concerned readers, suggesting that we do a thorough debunking of this product as we had with other power factor correctors (SILICON CHIP, November 2007 & May 2008).

However, I had not had a chance to respond to those emails when I was approached by *Today Tonight* for an interview on the topic. Apparently, a number of viewers had phoned the station to state that the product was "a load of rubbish" (or words to that effect) and that Seven should contact SILICON CHIP to find out the real story. "Would you mind doing an interview on the topic?" asked the Channel Seven researcher. How could I say "No"? And thanks to those readers for making the suggestion.

Today Tonight immediately sent out a crew and I prepared a demo to show what the product was supposed to do and how it could not save consumers money. The interview was done in great haste, with reporter Rodney Lohse in Brisbane via mobile phone while I was in our editorial offices. Being asked not to look at the camera but at a point on a bookshelf (to simulate talking to the interviewer) was distinctly odd, I can tell you.

As it turned out, probably due to programming constraints, *Today Tonight* did not run the whole interview but I was glad to get across the message that any device based on power factor correction could not save power and would result in no saving for the consumer. You can read the transcript at: **http://au.todaytonight.yahoo.com/article/8756894/consumer/power-saving-ideas**

The matter did not end there though because Channel Nine's *A Current Affair* had run a segment on a very similar product on the same night as *Today Tonight's* feature item. They also had received trenchant criticism from viewers and presumably, having seen my debunking of the concept on Tuesday, 2nd February, had decided to investigate further. They then asked the promoter to run through the demo again but this time showing readings in watts (power) rather than amps (current). This time the result was very different and the promoter was depicted in his self-induced destruction.

Having obtained such a damaging video, reporter Damian Murphy also visited our offices for an interview and a somewhat more detailed demonstration of power factor correction. This was supposed to go to air on Friday, February 6th but again, extended reporting on the aftermath of Cyclone Yasi meant that it was not featured. They duly apologised. However, *A Current Affair* did include a brief quote from an Emeritus Professor of Electrical Engineering and his words effectively administered the coup-de-grace to the product concept. Well done.

Several concerns still remain though. For example, on the Earthwise Power Savers's site it is possible to read an "independent report" which endorses the Powersaver product: **http://www.earthwisepowersavers.com.au/public/pdf/INDEPENDENT.pdf** It compares the energy consumption at different times of the year and makes no attempt to show differences with the device switched in or out. As such, the report is simply invalid.

Secondly, promoters of these sorts of products make outrageous claims about the quality of the electrical supply to homes. On the Earthwise Power Saver site you can see such drivel as: *"up to 30% of the billable electricity consumed in homes and businesses is non-productive and unusable. What this means is*

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MAILBAG

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Air-rifle is a restricted import

In your February 2011 edition on page 99 in the 'Ask SILICON CHIP' pages there is a letter (from R. K.) titled "Using the Beam-Break Trigger With An Air-Rifle". The letter describes an Airsoft gun capable of firing 6mm pellets at 240 feet/sec.

As well as being a subscriber to your magazine I also work for the Commonwealth organisation that regulates the importation and exportation of goods into and out of Australia. Whilst we could argue over the merits of the prohibition on such goods that is not the central issue.

It has been my experience that such items (1) generally fail the legislative requirements for importation (see URL); (2) the importer fails to seek the requisite permission to import said goods; and (3) the importer fails to declare the importation of such goods and or produce the permit at the time of importation. Of course, it is entirely possible that R. K. did obtain such a permit.

CUSTOMS ACT 1901 – SECT 233: Smuggling and unlawful importation and exportation:

(1) A person shall not:

(a) smuggle any goods; or

(b) import any prohibited imports; or

(c) export any prohibited exports; or

(d) unlawfully convey or have in his or her possession any smuggled goods or prohibited imports or prohibited exports.

Lastly, the possession of such goods is also an offence whether or not the individual concerned actually imported them.

It has also been my experience that persons regularly purchase goods via the internet without even considering the legality of what they may be doing – they may be completely unaware of any prohibitions or restrictions. Unfortunately this is not a defence – see **http://www.customs.gov.au/webdata/resources/files/ImportingSoftAirBB.pdf**

Name & address supplied but withheld at writers' request.

Grid-connect solar system results

I had a 3kW grid-connect solar panel system installed three months ago, on a north-facing roof at 15 degrees. While it is early days and the weather has been less than friendly, here are some observations:

(1) Lowest daily output (raining all day): 3kWh.

(2) Highest daily output (cloudless day): 21kWh.

At peak sunlight, 10am to 2pm, with a few clouds which occasionally shade the system, the output will go to a maximum of 3kW when the sun first hits the cooler panels. After a few minutes this settles to 2.6kW when panel temperature increases.

On a completely cloudless day the maximum output does not exceed 2.6kW. There are some ambitious claims made by certain installers.

At present the Queensland Government is paying 44c per kWh for excess generation. In light of recent severe weather events one wonders how long this will continue.

Ray Sonter,
Bundaberg, Qld.

Solar gross feed-in tariffs rob other consumers

I am busy writing a submission for the Senate Inquiry into rural wind farms. Otherwise I might be spending a bit of time trying, politely, to set the words down to point out to some of SILICON CHIP's contributors that perhaps they might like to think carefully about the social justice, indeed the injustice, of their being involved in the solar PV feed-in tariff scheme. They

Improving wireless broadband reception

Wireless broadband is increasingly popular and in most cases a very satisfactory solution where flexibility is required. I am a volunteer with Beyond Disability, a charity that provides computers, technical support and a Bigpond wireless broadband connection to the disabled for a nominal fee. We chose wireless as it is simple to administer as our users' circumstances change. In 95% of cases all goes well but the other 5% have difficulties due to poor reception in "difficult" areas or even buildings.

We are a technically able group but need advice on the practical solutions to poor reception – preferably at the lowest cost. We know that we could install outdoor Yagi arrays but this isn't feasible or economic in many circumstances.

It would be really useful to have an article that covers the reception issues for wireless broadband and the potential solutions. For instance, we have found that the simple add-on indoor 5dB antennas don't seem to do much but what about a glass mounted (through the glass) 9dB type car aerial? This has the advantage of being external (just) to the building and yet involves minimal installation work. I'm sure there are many possibilities; it's just that we don't have the resources or the necessary technical knowledge to know which would be the best options to trial.

I should mention in our location reception of Telstra's Next G is basically good but we still find "pockets" where even a mobile phone won't connect within the building.

Apart from our direct interest, I'm sure this would be of interest to the wider readership of SILICON CHIP.

Malcolm Fowler,
Mount Eliza, Vic.

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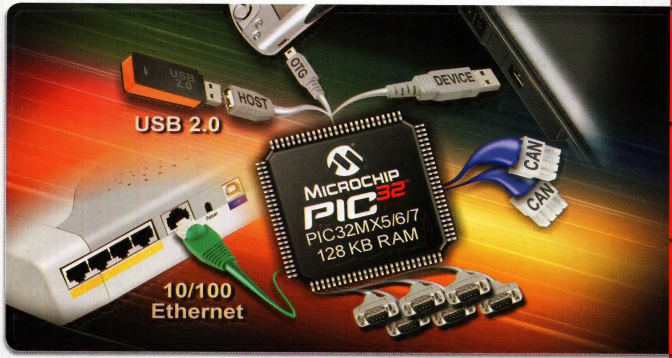

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MICROCHIP

Mailbag: continued

Confusion about the merits of power factor correction

After watching the Seven Network's Today Tonight (February 2nd, 2011) and seeing Leo Simpson discredit the makers of Earthwise Powersavers, I would like to know why you made an untrue statement, that because it is saving power doesn't mean anything and for any difference you have to save amps?

Well as an electrical engineering student at university, I know that P = VI so therefore saving power is saving amps since the voltage isn't changing.

I've never bought your magazine before and don't think I will in the future if the editor goes on TV saying untrue statements like this.

(M. R., via email).

Leo Simpson replies: unfortunately, you need to do more course work and also listen to the program more carefully. I stated that there was no point in reducing amps (ie, the current) and that what was important was the watts (ie, power consumed).

In the case of reactive loads, P = VI.cos(ϕ) where ϕ is the phase angle between voltage and current. When you correct for the power factor of an inductive load such as a motor, you reduce or eliminate the phase angle between voltage and current and you may also reduce the current. However, this does not reduce the overall power consumption since energy meters only respond to the product of voltage and in-phase current, as you say, P = VI.

So the paradox is that you can reduce the current but that has no effect on the energy consumption that the consumer pays for. In fact, the practical result is that the power consumption may actually rise very slightly. This was demonstrated on a similar item on the Nine network's "A Current Affair" on Friday, February 4th, 2011.

Unfortunately, due to programming constraints, the Channel 7 item did not show the actual demonstration that I prepared for them and that greatly reduced the overall information that I had provided.

Power factor correction is of no benefit to domestic consumers. Nor does it do anything to "clean up" the voltage waveform as the promoters implied and nor is the waveform as distorted as their video clips purport to show.

Power factor correction has been a feature of large industrial plants, such as rolling mills, for probably more than 100 years. Power factor correction using high-voltage capacitors has been in use for at least 60 years. Before high-voltage capacitors became available, power factor correction was done using large synchronous motors. If you complete your degree course, perhaps you might find out more on this topic.

We must emphasise that power factor correction and power factor correction using capacitors is certainly not a new technology, as implied by the promoters of these products. All these power factor correction gizmos promoted to domestic consumers have no benefit.

might like to think twice about rattling off performance data in SILICON CHIP's letters columns about their rooftops' solar PV system.

As an example, have a look at: **http://thegwpf.org/opinion-pros-a-cons/2309-ross-clark-how-to-warm-your-mansion-with-other-peoples-money.html**

Those graphs and my letters which you very kindly published (SILICON CHIP, January & March 2010) demonstrate the intermittent nature of the electrical garbage that comes from wind-farms, and are just as applicable to the power coming from rooftop solar panel installations. The resulting electrical noise input to the grid is even more pointless.

And regarding the letter that requested a comment on the idea that those so connected might further optimise their financial returns by purchasing power from the grid when prices are low, storing it in a battery for use during the day, and thereby sell more of their generated PV solar power at the higher tariff? Well, a rort by any other name is still a rort, only in this case, even more so. It would seem that lead-acid batteries have an operational efficiency of the order of 45-50% (see for example, Stevens and Corey 1996, available for viewing at: **http://www.scribd.com/doc/47637136/Stevens-Batt-Effic-at-high-SOC-SANDIA**

So even presuming that the PV power returned to the grid fully offsets the greenhouse gas emissions of that which might be otherwise used during the day, we still have the very uncomfortable fact that twice the "dirty" or "black" power has been consumed than would otherwise have been.

I do agree with the approach you took with the last line of the January 2011 editorial, suggesting that we should consider nuclear power. The alternatives are looking more and more useless, if that's possible, each passing day.

Paul Miskelly,
Mittagong, NSW.

Comment: we have always been of the opinion that all these government-sponsored initiatives to cut greenhouse gases have been a gross misallocation of taxpayer funds and that they do very little to mitigate greenhouse gases.

Still, it seems as though nuclear power may be back on the agenda. On February 4th, the Federal Energy Minister, Martin Ferguson, was reported as stating that Australia could be considering nuclear power in as little as four years. That is not to say that any concrete decision will be made in that time but at least it does indicate that there might be a significant shift in the political thinking on this topic.

Re-using microwave oven transformers

I have some comments on the recent letter about there being no point in rewinding microwave oven transformers (SILICON CHIP, January 2011, Mailbag, page 10). These transformers run with the core quite saturated (typically with 1.5A magnetising current) to provide some degree of voltage regulation. They also have magnetic shunts fitted

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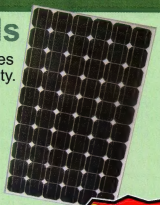

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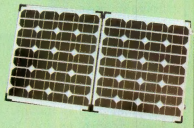

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Variac approach for hot-wire cutter

I see you had another hot wire cutter for Styrofoam in the December 2010 issue of SILICON CHIP. My father made a much simpler one from a Variac and a 240V/12V 100VA transformer.

You probably are well aware that a transformer can put out its rated secondary current at much lower than usual primary voltages. By using a length of resistance wire not much longer than the thickness of the Styrofoam, he only had to set the Variac to 12-24V to do the job.

You might say that the set-up is dangerous because the output of a Variac is not isolated but Dad was on the ball with mains wiring etc so he had a cover over the Variac terminals with a standard 3-pin socket on it. As the transformer had the usual 3-pin plug and lead, it could be plugged into a power point as usual with a 12V halogen lamp on the secondary to make a handy work light.

Jeff Paterson,
East Burwood, Vic.

Comment: there is no problem using a Variac in conjunction with a step-down transformer, as the latter will provide full isolation from the mains supply.

for the same reason. They are designed for intermittent use and will get very hot if used continuously.

To use them in an application where they run continuously the primary voltage must be reduced to around 120VAC and the magnetic shunts removed. Two identical transformers with their primary windings in series is the usual method of re-deploying these transformers, but this means twice the size and weight of a single transformer and potentially twice the rewinding effort. A 60-watt incandescent light bulb (if you can still get one) can be used in series with the primaries when experimenting with the phasing of the secondaries.

There is a very good article on reusing microwave oven transformers in the book "Radio Projects for the Amateur – Volume 4" by Drew Diamond, which is available from the WIA bookshop for around $25. There is also a very good article on rewinding transformers in Volume 2 of the same series.

The secondaries of microwave oven transformers carry very dangerous voltages and tests and modifications should only be carried out by suitably experienced people and even then extreme care is required.

I have been reading your magazine for many years now (in fact I started reading "Electronics Australia" in 1969) and I especially enjoy "The Serviceman's" column. Reading your magazine and building projects has given me much practical knowledge (something I find lacking in recent graduates) but I find there is not much to learn from many of your microprocessor-based projects without extensively commented source code.

How about a return to your fine tradition of education with more "how it works" information together with these projects?

Mike Hammer,
Mordialloc, Vic.

Comment: we have a section on how it works in every project article. We would like to do more on the details of software but space is quite limited.

Appeal for replacement of SILICON CHIP magazine collection

My step-father is an avid fan of SILICON CHIP and buys it religiously. He spends all of his spare time making little electronics projects from the magazine. His collection of SILICON CHIP and "Radio Wave" magazines dated back to 1938.

Sadly, he lost all of his magazines in the recent floods at Theodore, Queensland. I was hoping that some of your readers may have old magazines that they no longer need and would be willing to pass on to him. I would be happy to arrange postage.

I can be contacted at **mullerjanelle@gmail.com**

Janelle Muller,
Normanton, Qld.

Comment: unfortunately, we think there would be plenty of readers who have lost their collections due to floods and other disasters. But at the same time, there are plenty of other readers who want to give their old magazines away, due to restrictions on space.

We are happy to provide address or email details in the magazine for other readers who have lost their collections of SILICON CHIP in the recent floods and cyclone.

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Another approach to a PC bench power supply

Reading your article on the cheap high-powered bench power supply made from an obsolete computer PSU, I was struck by the fact that you had several warnings about the mains voltage in there. Thinking for a few minutes revealed a far safer option to turn a computer PSU into a bench supply.

Grab a metal case large enough to hold the PSU, a PC board, some meters, switches and connection posts. Cut a hole in the back of the case to mount the PSU, connect the PSU to the PC board along with as many of the drive connectors as can fit. Fit the board into the case and connect any meters, switches and the connection posts. Close the case up and you have a cheap bench supply with a replaceable PSU that is far safer to build and still far cheaper than what can be bought over the counter.

You can have switches that isolate the various outputs as well as an overall main switch. Meters can be fitted to show volts and current output which would be of great use to those that require the readings. Best of all, if the PSU packs it in, you can simply replace it as for a computer rather than having to spend time modifying another PSU.

Brad Coleman,
Burpengary, Qld.

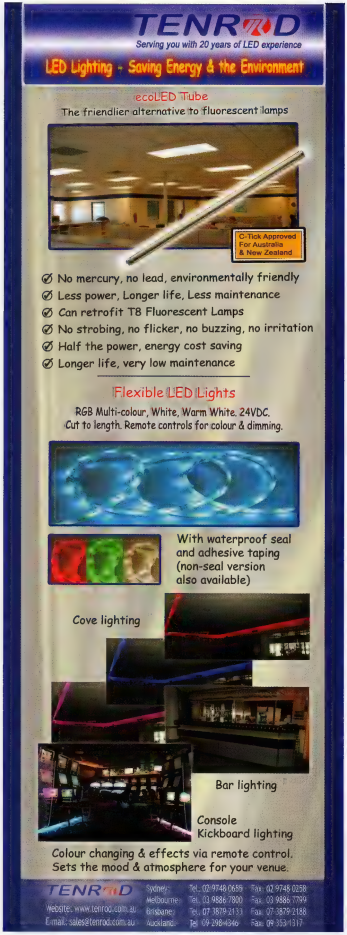
Comment: your approach is quite practical although it does require a lot more work. However, the big drawback is the need to find a suitable metal case as these can be expensive. Of course, you could use the PC case itself but we once took this approach with an audio amplifier (Ultra-LD Amplifier, Silicon Chip, May 2000) and were roundly criticised by some readers because it did not look good enough.

More information on 4-valve radio sets

In recent issues of Silicon Chip, there have been some interesting 4-valve radios described in the Vintage Radio column. It would have been interesting to have had actual sensitivity and distortion figures measured for the sets featured, to see if these odd circuit designs really worked as well as more mainstream designs.

In the article about the Astor DL 4-valve radio in the October 2010 issue, Rodney Champness states that AGC could have easily been provided. I disagree. Because positive IF feedback is used it would have been tricky to also have AGC with this set. Simple AGC would have reduced the gain too much at medium signal strength, as the positive IF feedback would also be reduced. Delayed AGC would have worked but would have required several extra components for the separate AGC circuit. The extra IF loading of the delayed AGC diode would also cause extra distortion for medium-strength signals.

To enable full output from the speaker, the IF amplifier should only have fractional AGC applied. In the actual circuit, the positive feedback will only work with the volume control cranked up, so it must have been of marginal usefulness. This "austerity" design gets its feedback, positive and negative, without using any extra



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Mailbag: continued

NBN is far too expensive

I refer to letters on the subject of the National Broadband Network in the January 2011 issue. Messrs Budde & Hackett are entitled to their opinions but I must strongly disagree with them. Labor's incarnation of the NBN is wrong, flawed and profoundly suspect on numerous levels.

For instance, just consider cost and ownership and as an analogy ponder this: Would you pay $1300 for a plasma TV, $3000 for wall mounts and then still agree to rent it for around $1900 per year? "Absurd", you would say. Well, the figures and the proportions are from the NBN implementation Study. $13 billion is the hardware, $30 billion (ie, 70% of $43 billion) is civil works and $19 billion is the current revenue from about 10 million premises. Proposed NBN rent figures are not much cheaper than current.

Messrs Budde & Hackett would provide a greater service to SILICON CHIP's readers by advising of the hardware costs (in bulk quantities) of single-mode and multi-mode fibre, optical switches and routers for same and other necessary hardware, plus other pertinent information that the government is not divulging.

J. M. Williams,
Carrara, Qld.

components, which is quite clever.

The receiver could have been designed as a reflex circuit with rather better performance, eg, the AWA Radiola Model 517-M (1948 but used pre-1939 valve types), which had delayed, fractional AGC on the 6A8G converter and 6G8G reflexed IF/AF stages, a 6V6 output valve and a 5Y3 rectifier. Curiously, in a later issue of SILICON CHIP (December 2010), the Philco 40-40 has a very similar circuit to the Astor's, again without AGC, but is reflexed (and is without the positive and negative feedback). The most satisfactory designs use only fractional AGC on the reflex stage.

It is interesting to speculate on how the Philco 40-40 was designed. The 6F7 may have been chosen because, as a triode-pentode, it offered the possibility of another amplifying stage without the expense of another valve. It was used in a number of Australian radio sets from 1934-39 but was rarely used after that. The octal version, the 6P7G, was also used in some Australian radio sets in 1939-41 (eg, Astor 910 "Mickey"). (See **www.radiomuseum.org**, which is a goldmine of information on vintage electronics).

I suspect that the 6F7 was first tried as a normal IF with the triode as plate detector and AF. The normal AGC circuit would not be possible with the plate detector. The 6F7 triode has a low gain, probably only about five, and the AF gain of the pentode as a reflex amplifier would be a good deal better, about 15, leading to the final circuit as built.

Alternatively, the distortion of the 6F7 triode plate detector may not have been judged acceptable or the circuit may have been too unstable, leading to the use of a diode detector. Having used a 7-pin socket for the 6F7, it was probably easier to retain it for the 6B7.

The circuit drawing of the Philco is badly drawn and very hard to read. Mr. Champness remarks that the second IF transformer is shown as slug-tuned in both primary and secondary but there appears to be a dotted line between the slug tuning symbols implying that they are mechanically connected. Usually in this type of IFT, with only one tuned winding, both coils are wound on the same former and the same slug tunes both.

Curiously, the secondary is shown tuned in the diagram but I thought that most single-tuned detector IFTs had the primary tuned. It would make more sense to have the secondary tuned if using a plate detector, as a step-up of the IF voltage could be made by using more turns on the secondary winding. With a diode or grid detector, the load on the secondary means that it is better to have the primary tuned.

Another interesting receiver from the same period, the Kreisler 510 of 1939, used an EBL1 output valve with signal diodes and used the 6F7 as IF and first AF with the usual 6A7

converter and an 80 rectifier making up a 4-valve receiver with 5-valve performance. The EBL1 being a European valve does not appear to have been available in Australia after 1939. The European-designed output valves EL3, EL3NG, EBL1 and others had a higher *gm* than the American 41, 42, 6F6G and 6V6G types that were usually used in Australia and would have been better suited to 4-valve receivers with their limited AF gain.

Robert Bennett,
Auckland, New Zealand.

Incompetent electricians raise questions about training

Your letter on the possible incorrect installation of solar systems in the January 2011 issue (page 10) highlights a general deficiency in trade training.

The following record of events demonstrates that qualified trades-people did not know how to carry out basic fault-finding on a hot-water system. The circuit is a simple series one comprising the element, an adjustable thermostat and a non-self-resettable (high temperature) safety thermal cut-out. The last two are contained in a single unit which attaches to the side of the tank.

Our Dux hot water system sprang a leak. A new unit was installed but then began a succession of disasters requiring seven further call-outs over a period of six weeks:

Visit 1: the hot water system was replaced. The original Dux M + J tariff (2 element) HWS was replaced with single element (J tariff) HWS.

Visit 2: no hot water. The electrician reset something in the corridor cabinet (it is in a block of apartments). It is a bit hard to know what exactly was done here as I did not talk to the person involved. I was not expecting continuing problems.

Visit 3: no hot water. The non-self-resettable thermal cut-out was reset. Every electrician/plumber subsequently just reset this cut-out without finding out why it tripped.

Visit 4: no hot water. The thermostat was replaced.

At this stage, the most reprehensible action of the whole debacle occurred. The thermostat was replaced but the installed device subsequently proved to be the wrong device (from an air-conditioning unit!) and a defective device. It contained no thermostat and just had a non-self-resettable thermal cut-out. This device was installed by the Dux plumber. The installed device could only overheat and cut-out every time. The device was so loose in its mounting we were fortunate it did even this.

Visit 5: no hot water. The heater element was replaced. The faulty thermostat could again only overheat and cut out.

Visit 6: no hot water. The J tariff timer was suspected and ETSA were called. ETSA confirmed the timer was OK. The faulty non-self-resettable thermal cut-out was reset but again, it could only overheat and cut out.

Visit 7: no hot water. The temperature on the thermostat was adjusted. The electrician/plumber did not even notice there was no thermostat behind the screwdriver adjuster. The faulty thermostat was reset but again, it could only overheat and cut out.

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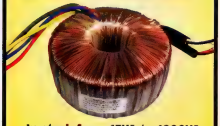

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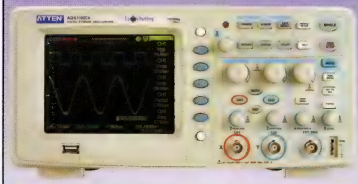

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Mains voltages may be higher than you think

Our church has a largish pipe organ with 2500 odd pipes. A few years ago, a decision was made to improve the bass end of the instrument, boosting the 16-foot ranks and providing two new 32-foot stops as well. Space was at a premium and as bass in organs translates to large pipes, electronic generation was investigated.

The church finally settled on a system devised by Petersons of the USA. All went well for a few months, with a very satisfying merging of the two different means of tone generation. But then output transistors in the power amplifiers began failing.

As you can imagine, the organists were not amused, especially as the instrument is also part of an organ school. Initially the faulty amplifiers went back to the US with no argument from Petersons. But after several failures the firm asked for more detailed information about the installation and that is where I came in.

The installation by the professional organ firm who look after maintenance and tuning of the instrument, seemed to have been done precisely in accordance with maker's instructions. Speaker impedances were spot on, with the specified cable gauge and run lengths used. Earths were OK too but the DC voltage across the output transistors was higher than that specified on the maker's circuit diagrams.

So at random times over a period of several days, I had a look at the mains voltages at the relevant power points feeding the electronic pipes. These were consistently in the high 250VAC range. Like many others, I had thought that Oz had adopted the 230VAC international standard so, on that basis, these voltages were way out of tolerance.

A phone call to the local supply authority, soon put me right about that! At least here in the ACT, 240VAC is still the mean standard. The American equipment was designed for 115V and the autotransformer supplied was designed to have 230VAC on its input terminals. So we obviously had a problem.

The technical branch of the power supplier did however agree to put a data logger on our supply for a week. This showed that although the supply was still within the -6% to +10% tolerances for a 240VAC supply, the average voltage we were receiving was closer to 250V than 240V. They agreed to adjust things at the substation and now our voltages are much more acceptable and we have had no further amplifier failures. All that was about four years ago.

With imported electronic equipment now manufactured for a supply voltage of 115V and/or 230VAC, I would suggest that if readers think they are having too frequent equipment or even lamp failures, a check of supply voltages may be in order.

For those readers interested, David Burger has drawn a chart which shows some of the supply voltage differences and tolerances to be expected around the country. Google 'What is the AC consumer supply voltage in Australia?' It is quite enlightening.

Bruce Bowman,
Ainslie, ACT.

Comment: for more information on this topic, see the article on the Mains Moderator on page 66.

Visit 8: no hot water. Dux electrician identifies the wrong thermostat and that it contained only a non-self-resettable thermal cut-out and replaces it. The system finally works.

It is hard to know exactly what the original fault on the new HWS was but the eventual replacement of the element and thermostat cured the problem.

John Dainty,
Bedford Park, SA.

5-axis hot-wire cutter can produce complex shapes

Your magazine has been of great interest to me for many years. Just recently two friends and I have installed Ultrasonic Anti-Fouling units on our boats, as per instructions supplied in your magazine (September & November 2010). Now is the time to wait to see if it works.

Another article which prompted me to write was the hot wire cutter in December 2010 issue and the follow-up letter in February 2011 on page 98.

I thought it could be of interest that one can take this type of cutting 3D shapes even further. The basic idea is to be able to make any shape of a model which was designed in 3D CAD. Conventional 4-axis hot-wire cutting is well established, especially in the signage industry. The advantage of using hot wire to do 3D shapes against conventional 3-axis milling is that it is silent and there are no dust particles of foam floating everywhere.

The accompanying photo shows the hull of a small model boat being cut. Practically any 3D convex shape can be cut, in the same way one can peel a potato with a knife.

If it was required, one could add a sixth axis output to control the angle of the frame holding the hot-wire perpendicular to the direction of travel over the surface. However, one can get away with 5-axis control only, since small variations in frame angle do not affect the resulting shape. That's provided the frame is large enough and the hot wire is in the plane derived from the "pretend" end face of the end mill used in CAD/CAM to generate the CNC code driving this type of machine.

Having a 5-axis router and Camworks CAD/CAM software allowed me to do this test.

This type machine and software did allow me to make many items. One of

the products which was developed some 10 years ago is depicted on my website www.soloray.com.au

Michael Haber,
Constitution Hill, NSW.

Domestic lighting restrictions in new building code

The letter from Alex Brown in the February 2011 issue about the new building code raises real issues regarding lighting. Our home is less than five years old but it would be a problem to get within the new limits for lighting power usage as quoted in that letter, using incandescent globes. The building is about 160 square metres inside. If built now, it would be allowed 800 watts of fixed lighting. We have a total of about 1.4kW of fixed lighting inside and six outside lights of 60W each and all of these are still original.

As well, we have a heat lamp/exhaust fan fitting in the bathroom in which the four heat lamps add up to 1kW. This, when converted to fluoro lighting, can be reduced to fall within the new building regulations except for the heat lamps but will still leave the problem of how does one calculate the allowance? Is it on a per fitting for the area it is to light basis or is it a total for the building? If per fitting then the pantry will be lit by less than a 5-watt globe while the external ones would have the largest globes and so on.

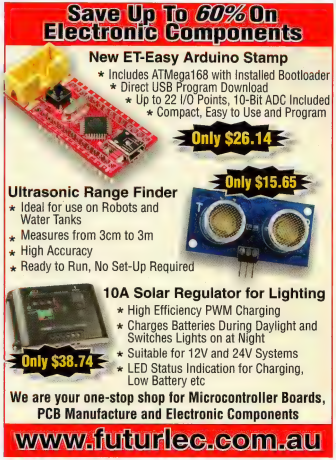
As well, it was explained to me many years back by an eye specialist that, in order to get correct lighting on your work etc, you need to be no more than 1.5m from a fluoro light and preferably just one metre due to the rapidly reducing intensity of the light. As a result, the fluoro over my office desk was lowered to be only slightly more than a metre above the desk so I could once again see clearly and do my work.

The only real alternative then becomes LED lighting. Otherwise, a lot of power points are needed for all the pluggable lights as this way we can by-pass the regulation on fixed lights and still have light as and where needed. This is not as safe as hard-wired installations are. Just look out for all the cords laying on the floor.

Another point is just how the total is calculated. Is it on the maximum allowed in a fitting or is it on the actual globes installed? This will affect the way the total is calculated and therefore who is liable to correct the situation. Should the wise men decide to reduce the number of power points per dwelling to some strange formula that has no real meaning in life then the retailers will only clap their hands as the extra number of pluggable power boards etc needed to overcome the problem will definitely have a beneficial effect on their bottom line. So is it the regulators only or is big business also working on a way to profit from over-regulation? Or am I getting too cynical in my old age?

Jan Boers.
Cookernup W.A.

Comment: as we stated last month, this regulation is misguided. It is probably aimed at reducing the excessive numbers of halogen down-lights that seem to the fashion in houses with low ceilings (2.4 metres). SC



Name something which is very useful, where you get more than you will ever likely need and at a cost that is trivial. Enter the newest processor in the Microchip stable:

The Microchip PIC32

By Geoff Graham

Here is a scenario that will be familiar to anyone who has built a few projects based on microcontrollers...

You have selected a chip (probably one that you are familiar with) and as you add more and more features, you realise that it will not have enough capacity for what you want to do.

So, it is out with the catalog to find another chip that is a few rungs up on the capacity ladder and redesign the project to use that. Then later, possibly on a new project, you would find yourself running out of capacity again... and it would be back to the catalog again.

After a few cycles of this, the idea occurred to me, why not just pick the biggest, meanest and fastest chip that I could find and never again worry about running out of capacity? How hard could it be to use one of these things anyway?

Well, the answer turns out to be – not very hard at all! In fact, using one of these high powered chips is just as easy as using the simple 8-bit chips that most of us are used to.

So, this is what this article is about: to introduce you to the most powerful chip that Microchip makes and show how easy it is to use this monster, for even the simplest of tasks.

Just to set the scene, the chip that we are talking about costs only US$8.75 in one-off quantities and contains the same 32-bit central processor design that powered huge business minicomputers just 15 to 20 years ago.

The PIC32

The current top of the range microcontroller from Microchip is the PIC32MX795F512H-80I/PT (I will call it the PIC32 for short). It has a 32-bit processing core running at 80MHz, 512KB of flash memory and 128KB of RAM with built in USB, Ethernet and CAN networking.

You might think that all this power and capability would involve a much greater complexity and cost when compared to their simpler 8-bit brethren.

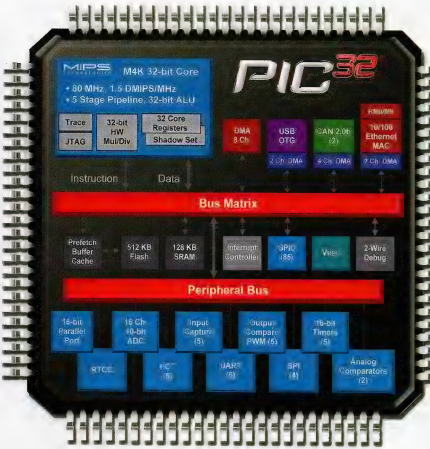
This is not so and is partly because Microchip want to make it easy for you to use the chip.

Microchip can see the future in these products so they make available cheap development hardware, good compilers and extensive software libraries. All this is with the intention of making it easier for engineers to design these microcontrollers into future products, which Microchip hope will in turn result in orders for thousands of chips. You may be only planning to use a few chips, or even one but you too can benefit from this marketing push.

In fact, in many ways, it is easier for a hobbyist or small scale developer to utilise the 32-bit chips than it is to use the old 8-bit chips.

You do not have issues with odd architectural limitations, the speed of the chip can overcome inefficiencies in your code and you do not waste time counting bytes to fit into a limited memory space.

Marvellous that this chip is, it is still not the best choice in every circumstance. Many times a microcontroller



This is the official diagram for the PIC32 chip and if it looks complex, that is because it is! There is a lot packed away inside the chip which means that you can reduce the number of support chips to a minimum. (Courtesy Microchip)

is just used as a replacement for hard-wired logic and in such a simple application you are better sticking with simple 8-bit chips. A good example is the Ultrasonic Cleaner described a few months ago in SILICON CHIP.

However, if you are embarking on a project with moderate complexity - for example including USB, graphics or some heavy calculations then you would be much better served by going with this powerful chip.

You might feel that this enormous power will be wasted on a modest project but that is not the point. At such a cheap price it does not matter if most of the chip's capacity is idle. The important point is that you have a single platform that will handle almost anything that you can throw at it; no more trying to squeeze code into a limited space, no more counting I/O pins just to discover that you will be a few short and no more desperate searching of the catalog.

The only significant issue is that the PIC32 comes in surface mount TQFP packages. But we have an easy way around that problem, which we will describe later.

The details

During the rest of this article I will be comparing the PIC32 to the 8-bit 18F4550 microcontroller. This is quite a powerful chip used in several SILICON CHIP designs and in itself is many times more powerful than the simpler chips used for logic replacement duties.

As mentioned before, the PIC32 chip that we are looking at has 512K of program memory, 128K of RAM and runs at 80MHz. 512K of program memory is a lot and depending on how you use it you will have about 10 times the capacity of the 18F4550.

Elsewhere in this issue we put this power to work, with the "Maximite", a microcomputer with a BASIC interpreter, video output, USB and a FAT16/32 file system and only uses one third of the 512KB available. Similarly, 128K of RAM is huge compared to the 2K provided in the 8-bit chip.

The PIC32 runs at 80MHz and will execute one instruction for (almost) each clock cycle, so it is executing one instruction every 12 nanoseconds - very fast indeed. For comparison, the 18F4550's clock can run at 48MHz but it can only execute an instruction every four cycles. Coupled with the fact that the 32-bit instruction set is more efficient, this means that the PIC32 will run least 10 times faster.

So, 10 times more capacity and speed. What does this mean in practice? It means that you do not need to optimise the code, worry too much about speed or limit yourself in the number of features that you want to include. It also means that you can include sophisticated libraries like the TCP/IP protocol stack, a web server, USB protocol etc without hitting limits

Tandem Computers built in the 80's and 90's used multiple MIPS CPUs and were widely used in banks and large businesses for reliable and high capacity data processing. The PIC32 actually has more processing capacity than the core CPU powering this computer system!

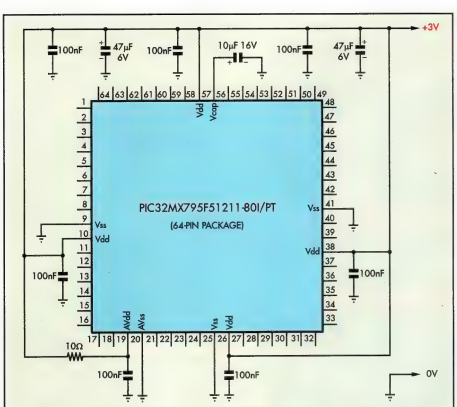


Fig.2: the schematic for the breakout board is simple and consists mostly o f decoupling capacitors for the power supply. The four capacitors depicted in the top left of the diagram are mounted on top of the board and the rest are underneath (see the text).

related to capacity or speed.

As an example, in a recent project I needed the micro to calculate the time of the local sunrise and sunset given the latitude/longitude and date of the year. This involved the tilt of the earth and its orbit around the sun and used quite complex 3D calculations with double precision floating point numbers. The result, which would have been beyond the practical capacity of an 8-bit chip, used only 5% of the PIC32's program memory and executed seemingly instantly.

32-bit core

The PIC32 is described as having a 32-bit processing core (or CPU). But just what does that mean?

The processing core used by Microchip is a MIPS Technologies design. MIPS first developed their processor design in the early 1980s.

It went on to become the central processing core of many of the advanced computers of the 1990s from companies such as Silicon Graphics, Pyramid and Tandem. It has been improved and extended since then and is now one of the top processor cores powering the more powerful microcontroller chips.

This demonstrates a recent trend where companies that specialise in the development of processor cores and instruction sets licence their design to chip manufacturers such as Microchip.

This is because it is extremely difficult for manufacturers to develop the processing core and supporting technologies (compilers etc) on their own and consequently it is much easier to adopt a proven design like the MIPS.

The MIPS core is available as a 32 or 64-bit design and Microchip chose to implement almost the entire 32-bit core in their chip. The term 32-bit means that each instruction is 32 bits (4 bytes) in size and arithmetic operations (add, subtract etc) are carried out using 32-bit arithmetic.

This last point is important as 8-bit microcontrollers use just eight bits for arithmetic operations and so they are limited to manipulating numbers up to a maximum of 255 in a single cycle.

The C compiler or assembler writer for an 8-bit processor will get around this by using multiple instructions to handle a larger number but this is slow and inefficient, especially where multiply and divide are concerned.

With a 32-bit core you can manipulate numbers up to 4,294,967,295 using a single instruction. Most of the data that you will want to process (be it seconds, cycles etc) will be more than 255 and less than 4 billion, so 32-bit arithmetic is very handy and makes writing software for the PIC32 much easier than with an 8-bit chip.

Lest you think that a 16-bit microcontroller will be OK, just consider that they can only natively work with numbers up to 65,535; still rather limiting.

32-bit also implies many other features including a larger memory address range, more efficient memory access, more CPU registers for efficient processing, a more powerful instruction set and sophisticated handling of interrupts.

A tour of the chip

Other than features like speed, capacity and processing power the PIC32 also has plenty of I/O and other peripherals integrated onto the chip to make the developer's life easier.

The chip is available in 64 and 100-pin packages. Some of these pins are used for power, ground, clock etc with the result that you have 48 I/O pins available (on the 64-pin package).

When various peripherals are enabled (for example, Ethernet or USB) they will take over some of the I/O pins, so the number available for general use is normally less than 48.

However, if that is not enough you

To program the PIC32 you will need a programmer. This is the PICkit 3 from Microchip and it offers exceptional value, being not only a programmer but also a debugger, allowing you to trace program execution and examine individual memory locations and registers inside the chip. (courtesy Microchip)

can always use the 100-pin package which has 78 I/O pins available.

The outputs can be of the conventional type where the chip can source or sink 18mA but they can also be configured for an open-collector output which makes it easy to interface with chips running at 5V.

When configured as digital inputs, most pins are 5V tolerant and have a Schmitt trigger input to reduce issues with pulses that have a slow rise or fall time.

16 of the I/O pins can be configured as analog inputs and the analog to digital converter itself is very fast with speeds of up to a million samples per second.

The USB interface can operate in a number of modes. These are a device mode where the chip acts like a peripheral to a host computer; a host mode where the chip acts as the computer and can communicate with things like USB sticks or printers or the On-The-Go mode where it can dynamically switch between device and host mode.

The Ethernet interface supports 10/100 speeds but it does not include the analog circuitry to drive the normal twisted pair Ethernet cable.

This means that you need an external chip (called a physical interface or PHY) to complete the Ethernet interface. Microchip recommend a number of chips and they are reasonably simple to use with the PIC32.

An integrated Controller Area Network (CAN) module supports CAN 2.0B networks and can be used to interface to modern vehicles using the CAN protocol and ODBC-II. CAN networking is also used in marine instrumentation, medical equipment and other areas.

The chip also includes the many standard peripherals that you have come to expect on a microcontroller. These include multiple timers, serial interfaces such as I^2C, SPI and UART, parallel interfaces, DMA, real time clock, etc. We do not have the space to go into the details so you should consider downloading the "PIC32 Family Reference Manual" from microchip.com to find out more.

All this capability consumes about 120mA at 3.3V with everything running at full speed. But you can leave parts of the chip turned off and when you throttle back the clock speed (all under program control) the current will drop to as little as 1 or 2mA.

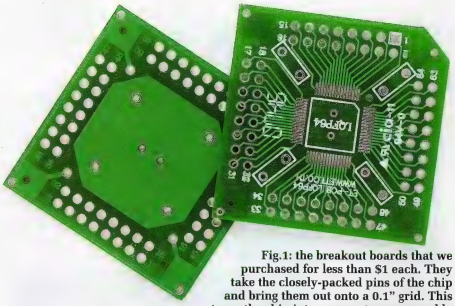


Fig.1: the breakout boards that we purchased for less than $1 each. They take the closely-packed pins of the chip and bring them out onto a 0.1" grid. This turns the chip into an easy-to-use assembly that you can plug into a breadboard or solder to.

Using the PIC32

The first requirement for most developers is to identify the compiler and development environment that they can use. As mentioned before, Microchip wants you to use the chip so they make it as easy as possible to develop software for the chip.

The full Microchip C compiler for the PIC32 costs about $1,000 but they also provide a free version (called **the** "Lite" version), which is exactly the same but with a few of the optimisations disabled. The missing optimisations do not make a huge difference in the speed or size of the resultant program and, as you have a chip which is 10 times better in most aspects, you will not notice this difference.

When you install Microchip's free development environment (called MPLAB) you also automatically install the PIC32 C-Compiler. This will run in full evaluation mode for 60 days before it switches to the "Lite" version. Either mode is fine so you do not have to do anything.

This software package also includes an assembler for anyone that might want to write in assembler but with something of this sophistication, the C language is the only way to go. And sorry, if you are a fan of BASCOM, Pascal or other languages, they are currently not available for the PIC32.

As part of the C compiler you also get an extensive software library which includes functions for dealing with most of the hardware features of the chip. For example, you generally only need a couple of lines in your program to set up a peripheral. These functions simply call the software library which does the hard work.

If you want to use some of the more sophisticated features of the chip you can download libraries from Microchip containing a full TCP/IP protocol stack, web server, FTP client, USB protocol stack, FAT file systems for SD cards and more. All of these have been written and tested for the PIC32 and are free.

You will also need a programmer to load your compiled code into the chip. The PIC32 series is programmed using the ICSP interface on the chip and arguably the best programmer for this job is the Microchip PICkit 3. This costs just US$45 from [microchipdirect.com] and for what it does, represents great value for money.

The PICkit 3 was described in the July 2010 issue of SILICON CHIP and not only does it program your chip, it also acts as a full function debugger. Using it you can set a breakpoint in your code and when the program stops at this point you can examine variables, hardware registers, etc. You can then single step the processor through your code while watching exactly what it is doing. It is like having a window into the inside your chip.

Prototyping with the PIC32

The one issue with the PIC32 is that it comes in a TQFP surface mount package with pins that are very fine and close together. This might sound like a "deal breaker" but it is not.

You can purchase "breakout" boards

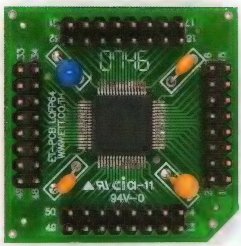


Fig.3. The completed breakout board showing the PIC32, the header pins and four of the decoupling capacitors mentioned in the text. The chip was hand soldered to the board and if you look closely you can see that the result is quite reasonable.

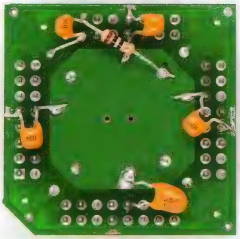


Fig.4. The underneath of the breakout board showing how we soldered the decoupling capacitors as close as possible to the chip. We used the centre copper pad for the 3.3V supply and the track running around the periphery for the ground. The resistor is used for additional noise reduction in the power supply to the analog portions of the chip.

that take the fine pitch leads from the chip and spread them out to standard inline pins with an easy to use 0.1 inch pitch. Fig.1 shows an example of a breakout board that we purchased from **futurlec.com** for $1 (part code: 64PINLQFP).

You can also find these and similar boards on eBay – look for a board that is suitable for 64-pin TQFP or LQFP packages with pin spacing of 0.5mm.

With the PIC32 chip mounted on the breakout board you can treat the board/chip combination as a large plug-in chip. You can plug it into a motherboard, wire wrap to it or solder direct to the solder pads or header pins.

This approach also makes prototyping with a breadboard easy. We sat our breakout board beside the breadboard and used jumper leads from the breakout board to the breadboard.

Fig.6 illustrates this setup. The result is that you can completely test your design on a breadboard before you start building the finished product.

The jumper leads that we used are 12cm long and have a male pin at one end and a female socket at the other. Ours came from **schmartboard.com** (part 920-0023-01) but you can also buy them from **sparkfun.com** or make up your own using a female socket (Jaycar HP1260) and pins taken from a header strip (Jaycar HM3211).

Soldering the Chip

The first step in assembling the breakout board is to solder the PIC32 chip to the board. SILICON CHIP has described this process a number of times and if you scan the Internet you will find numerous techniques for soldering surface mount components using heat sources from a hot air gun to an electric frying pan and most of these will work.

However, for just one chip it is easier to simply solder it using a soldering iron and that is the method that we will describe here. This process might sound complicated but it is not and when you have done it once you will wonder what all the fuss is about.

First you need three tools: a A temperature controlled soldering iron with a small chisel tip (0.8mm is optimal), a magnifying loupe with a power in the range of x5 to x15 (x10 is about best) and a liquid flux. You can buy the flux from Jaycar (Cat NS3036) or Altronics (Cat H1650) and you will find the magnifying loupe at any good optical supplier or on eBay.

When you solder the chip you should melt the solder onto the soldering iron tip and carry it via the iron to the joint. When you do this the flux in the core of your solder will evaporate, so you need the separate liquid flux which should be applied liberally over the solder pads and the legs of the chip before you start.

First position the chip accurately on the board and then, while holding it down with a matchstick, apply some flux and then solder one or two pins at opposite corners of the chip. Keep an eye on the alignment during this step and if it has slipped you should correct it before moving on.

Then, liberally apply the liquid flux on all of the pins. With the alignment correct and the pins covered in flux you can then progress steadily around the chip soldering all the pins.

The secret to the technique is to only use a little solder, just wet the iron. If you have a visible blob then you have too much. If in doubt, start with a small amount of solder and work your way upwards.

As you look through the magnifying loupe, the soldering iron tip will look like a huge bar of metal the width of three or four pins on the chip. You should place it on the pins and press

Parts List (for the breakout board)

1 Breakout board for 64 pin TQFP package. (Available from **futurlec.com**; part code 64PINLQFP.)
1 Dual row header pins (Jaycar HM3212 or Altronics P5410)

Semiconductors
1 PIC32MX795F512H-80I/PT microcontroller.

Capacitors
2 47µF 6V Tantalum
1 10µF 6V Tantalum
5 100nF Monolithic

Resistors (0.25W 5%)
1 10Ω

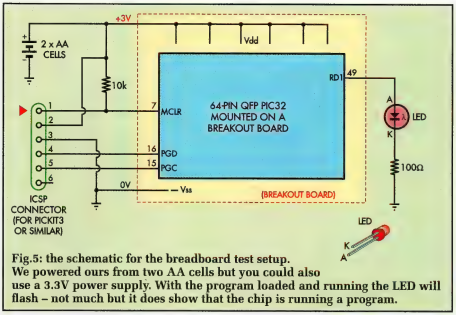


Fig.5: the schematic for the breadboard test setup. We powered ours from two AA cells but you could also use a 3.3V power supply. With the program loaded and running the LED will flash – not much but it does show that the chip is running a program.

the pins gently down onto the solder pads for one or two seconds. Encouraged by the liquid flux, the solder will quickly flow off the iron and onto the pins and solder pads. However, because you have only a limited amount of solder on the tip, it will not form a bridge between pins even though your iron is soldering three or more pins at the same time.

The reason for the chisel tip on the soldering iron is that this tip will hold the solder while you carry it to the joint. A very fine tip cannot hold the solder which defeats this technique. Another benefit with the chisel tip is that you can turn it sideways and then you can solder just one pin at a time. However, this does take a very steady hand and a better magnifying device such as a wide field microscope.

Even better, if you have an iron with a "wave soldering" tip as described in the December 2010 issue of Silicon Chip you could use that soldering technique.

While you are soldering don't worry if you do form a bridge, just reduce the amount of solder that you are using and carry on around the chip. Later you can come back and use desoldering braid to suck up the excess solder that formed the bridge.

You do need to be careful when using desoldering braid as it tends to suck up all the solder, including the solder joining the pins to the PC board pads. This will leave you with an open or intermittent joint that will be very hard to find later. The force applied when using desoldering braid can also bend the pins (they are very thin) and push them out of alignment. Use the braid sparingly and check and resolder the joints if necessary.

A similar technique (often called the blob solder method) was described by Nicholas Vinen in the October 2009 issue of Silicon Chip. In this you start by using excess solder and rely on the desoldering braid to remove the excess later. This works just as well so you can use whichever technique suits you.

When you have finished you should use a multimeter set to the continuity (beeper) range to check for shorts between any two pins. Also, check that there is continuity from each pin header pad to the pin on the chip. You could find a few hidden shorts or open pins so don't skip this step.

Because the PIC32 chip and breakout boards are so cheap you should consider buying two or three of them

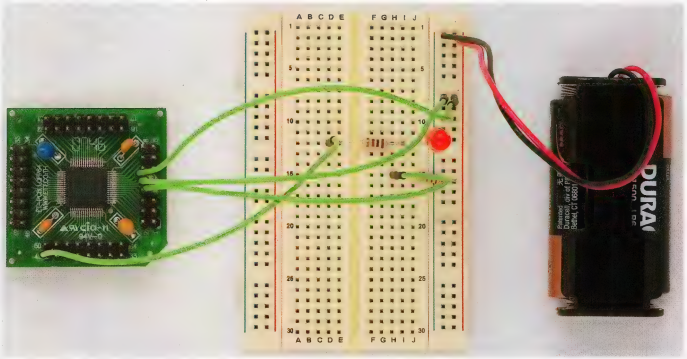


Fig.6. This is the completed breakout board running the test program. We used jumpers to connect the PIC32 to the breadboard and two AA batteries for the power supply. Cost of the parts is about $12!

Purchasing the PIC32

You can purchase the PIC32 direct from Microchip in the United States for US$8.75, even if you are buying just one chip. Their website is www.microchip.com and the chip you need to purchase is the PIC32MX795F512H-80I/PT.

Microchip's freight charges are reasonable but if your order value is less than $25 they will charge a $5 handling fee – so it is worth purchasing a few of the chips or something else at the same time.

At the time of writing SparkFun (www.sparkfun.com) have a limited quantity of this chip on special for $7.95 and their freight/admin charges are even more reasonable.

so that you are not too concerned if you do ruin one. This is where Murphy's Law will come in – if you do buy some spare chips you will probably find that your first effort will be completely successful!

Finishing the breakout board

Once the PIC32 chip is in place you can then solder the pin headers around the periphery of the breakout board. These are dual row pins that are snapped off to the appropriate length from a single 40 pin length (Jaycar HM3212 or Altronics P5410).

You also need to solder a number of decoupling capacitors to the reverse of the board. These are important because at full speed the PIC32 draws about 120mA with significant high speed spikes in the current draw. Unless the decoupling capacitors are present the chip will hang or crash when you configure it for high speed operation.

These capacitors need to be mounted as close to the chip as possible so you should solder them to the reverse side of the header pins. Fig.4 shows our completed breakout board with the capacitors mounted on the reverse side.

The table below lists the values and locations of these capacitors for a 64-pin PIC32 chip.

Capacitor	Between Pins	
100nF monolithic or ceramic	10	9
100nF monolithic or ceramic	19	20
100nF monolithic or ceramic	26	25
100nF monolithic or ceramic	38	41
100nF monolithic or ceramic	57	25
10µF 6V tantalum	56(+)	25(-)

The 10µF capacitor is used to smooth the internal 1.8V voltage regulator for the central processing core. This must have a low series resistance and for that reason we have specified a Tantalum type. This is polarised so make sure that you solder the positive leg to pin 56.

To make it easier to deliver power to the assembly you should join all the power pins together as shown in Fig.2 and Fig.4. These are pins 9, 20, 25 and 41 for Vss (ie, ground) and pins 10, 26, 38 and 57 for Vdd (ie, +3.3V). Pin 19 (Avdd) should connect to Vdd via a 10Ω resistor as this will provide additional decoupling for the analog circuitry. We used the copper pad in the centre of the breakout board for Vdd and the copper track running around the edge of the board for Vss.

Our breakout board also had positions for four extra capacitors between the centre copper pad and the track running around the edge. You should install a 47µF 6V Tantalum into two of these locations and, on the theory that you cannot have too many decoupling capacitors, we also put 100nF monolithics into the two remaining locations.

The resultant assembly will run at the full speed of the chip (80MHz). Not bad considering that the chip is mounted on a general purpose test setup and not a purpose designed PC board.

The Test Set-up

For out test setup we simply used jumper leads to connect the header/chip combination to a breadboard. Fig.5 shows the schematic and Fig.6 shows the complete test setup.

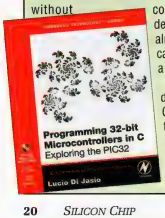
The PIC32 will run on any supply voltage from 2.3V to 3.6V and this makes it ideal for running from a couple of AA batteries. We had the chip happily running at 80MHz with the battery supply and it makes for an easy test setup.

The test circuit is very simple; it just flashes a LED off and on. But in getting this to work you will have jumped over many hurdles in correctly connecting up the chip, running the compiler and programming the chip.

In programming circles this is called a "Hello World" program. Its objective

More resources

If you would like an easy introduction to the PIC32 then the book "**Programming 32-bit microcontrollers in C. Exploring the PIC32**" by Lucio Di Jasio (ISBN: 0750687096) would be an excellent choice. The author focuses on the PIC32 so everything in the book is relevant and he takes the reader on a journey from the basic to the complex without confusing you or leaving you alone in the deep end. During the journey he explores almost every aspect of the chip so you can keep the book on your bookshelf as a handy reference.



The book has plenty of examples and does not assume that you are a proficient C programmer. It even includes a brief tutorial on the language and all his examples are complete and ready to run.

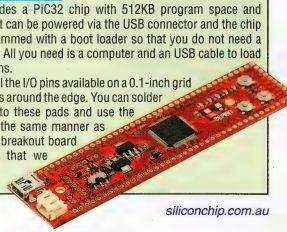
This book is available from the SILICON CHIP bookstore.

If you don't want to solder your own chip to a breakout board you can purchase one of many pre assembled development boards that are available.

A good example is the "USB 32-Bit Whacker" (illustrated below) from www.sparkfun.com

This includes a PIC32 chip with 512KB program space and 32KB RAM. It can be powered via the USB connector and the chip is pre programmed with a boot loader so that you do not need a programmer. All you need is a computer and an USB cable to load your programs.

It makes all the I/O pins available on a 0.1-inch grid of solder pads around the edge. You can solder pin headers to these pads and use the assembly in the same manner as the chip and breakout board combination that we described.



Test Program

```
1:                                          // Configure for 20MHZ using the 8MHz internal oscillator
2: #pragma conFig.FNOSC=FRCPLL, FPLLIDIV=DIV_2, FPLLMUL=MUL_20, FPLLODIV=DIV_4
3:
4: #include <plib.h>                        // include PIC32 peripheral library
5:
6: main() {
7:   int i;
8:
9:   SYSTEMConfigPerformance(20000000);     // optimise for speed
10:  mPORTDSetPinsDigitalOut(BIT_1);        // make RD1 (LED) an output
11:
12:  while(1) {
13:    mPORTDToggleBits(BIT_1);             // flip the LED off/on
14:    for(i=0; i<416000; i++);             // 250mS delay at 20MHz
15:  }
16: }
```

Line 1: Comments start with a double slash (//)

Line 2: This sets the configuration parameters for the chip (sometimes called the "fuses"). The first entry (FNOSC=FRCPLL) sets the clock source to the internal oscillator (8MHz) via the phase locked loop (PLL). The second entry causes the oscillator to be divided by 2 before being applied to the PLL. The third entry sets the PLL multiply ratio to 20. This means that the internal oscillator after being divided by 2 will be multiplied by 20 thereby giving an output from the PLL of 80MHz. The last entry causes the PLL output to be divided by 4 before being used by the core processor, which therefore runs at 20MHz. By varying this last entry you can change the core speed with DIV_1 giving 80MHz and DIV_2 giving 40MHz.

Line 4: This includes standard code that defines the library functions that we will use.

Line 6: The program starts running at the beginning of the function main(). The curly bracket marks the beginning of the function and the closing bracket on line 16 marks the end.

Line 7: We define an integer variable for later use. Note that all integers default to a signed 32-bit number (ie, it can be -ve or +ve).

Line 9: This calls a library function to optimise the chip for the clock speed that we are running at (20000000 Hz). The optimisations include setting up the instruction cache and wait states for memory access.

Line 10: This calls another library function to set RD1 as an output. RD1 is pin 49 on a 64 pin chip.

Line 12: This sets up an infinite loop so the LED will keep flashing forever.

Line 13: We call another library routine to toggle the state of the RD1 output from high to low or vice versa. This is where the LED is turned on or off.

Line 14: This is a delay routine to prevent the LED from flashing too fast. Running at 20MHz, counting to 416000 takes about 250ms.

is not to do anything useful but to simply check and prove that all the components are working correctly. With this running you can then move on to something more serious (and hopefully, useful).

Running the test program

The "Test Program" panel above lists a program that will make a LED flash in the test setup.

To compile this program you will need to install the latest version of Microchip's MPLAB and start it up. As explained previously, it is available as a free download from Microchip (microchip.com).

Once MPLAB is installed you should select Project->Project Wizard to step you through setting up a new project.

You will have to tell the wizard what chip you are using (PIC32MX795F512H) and select the active toolset (Microchip PIC32 C-Compiler).

Add a new file to your project (eg, test.c) and type in the test program (without the line numbers). You should now be able to compile it simply by pressing F10.

The final step is to connect your programmer, enable it, program the PIC32 and tell MPLAB to run the program. You should then be rewarded with the LED steadily flashing off and on.

Because the program is so simple there is little to go wrong with it but there are many other factors that might trip you up the first time – after all this is the purpose of a test program like this.

Firstly the compiler should tell you if it has found a mistake in the program but some mistypes can slip through, so recheck what you have entered.

When you enabled the programmer it should have told you if it could see the PIC32 – if this failed you should check the power supply, the cables/connections and your soldering.

If the programmer completed its job without complaining but the LED did not flash you should check that all the capacitors are present and that power and ground is present on all the pins listed earlier.

It is also possible that the PIC32 cannot run because of noise on the power supply leads and you could try shortening the jumper leads and/or adding some more decoupling capacitors on the underside of the breakout board between Vdd and Vss.

The test program runs the chip at a slow speed (20MHz) so you should not have too much trouble getting the chip to run.

So, now that you have the chip up and running, what are you going to do with it? Whatever you choose – it is unlikely that this chip will limit your ambition. SC

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DickSmith 100g Lead-Free Solder Roll
A lead-free 1.0mm solder alloy containing flux for general electronics work where earlier lead-based solders cannot be used. This solder is 99.3% tin and 0.7% copper. Use with iron-clad or nickel-clad soldering iron tips. 100g roll.
Not carried at all stores, but can be ordered in. Limit of 2 rolls per customer. N2630

$9.95
SAVE $5

Dick Smith
Helping Hands with Magnifier
Heavy cast-iron base for stability, a magnifying glass, plus adjustable position alligator clips to hold an item still while you're working on it. Not stocked in all stores, but can be ordered in. T5715

Dick Smith 25W Soldering Iron
Basic 25W soldering iron, 240V operation, 370°C operating temperature, replaceable tip, includes mini stand. T2304

$9.99
SAVE $5

$36.80
SAVE $10

Weller
11W Battery Powered Soldering Iron
Use where mains power is not available, provides up to 510°C tip temperature, conical plated tip, lead-free solder and protective cap. Requires 4 x AA size Alkaline batteries (not supplied). Not carried in all stores, but can be ordered in. T2507

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te Technology Destination

Targus

Mobile DC Laptop and Phone Charger

Super-compact power solution for charging 2 devices at once in your car (e.g. one laptop and a mobile device like a phone or MP3 player). Ideal for travellers, it is supplied with 9 laptop tips, an iPod/iPhone tip and a mini-USB tip for mobile phones. Simply plug into the cigarette lighter socket in your car, attach the appropriate tip/s, and you're under way. M9061

$99

NEW

Targus

90W Notebook AC Power Adaptor

Ideal as a replacement or second power supply. Suits a wide range of today's 19-20 volt notebooks by simply changing the DC output tip. A range of tips are provided so it's a great solution for the user who needs a lightweight and slim power solution at home or in the office. M0666

$99

GREAT VALUE

$12.99

SAVE $7

Dick Smith 41-Piece Bit and Socket Set

Consists of 32 security bits, nine Hex sockets, and a right-angle driver handle, all packed neatly into a plastic storage box with a clear, flip-up lid. Each bit is made from tough steel alloy. Not stocked in all stores, but can be ordered in. T4511

Dick Smith Digital Palm Multimeter

Solidly built multimeter with high visibility backlit screen, 18 ranges inc DC current to 10A, over-moulded rubberised protective side covering, test leads and battery. Includes diode and continuity tests, data hold, and square wave output. Not stocked in all stores, but can be ordered in. Q7409

$14.98

HALF PRICE

$39.98

Dick Smith Regulated AC Adaptor 4.5V - 12V DC 2.5A

Compact and powerful AC adaptor for equipment that requires a higher current source than standard AC adaptors. 4 switchable DC output voltages (4.5, 6, 9, and 12V), and can provide up to 2.5A current for each voltage. Includes 8 different sized DC output tips. M9985

Dick Smith Contact Cleaner

An aggressive contact cleaner for use in cleaning metallic switch contacts in the general electronics area e.g. TVs and older PCs. Not for use with plastics. Highly flammable. 190g can. Not carried at all stores, but can be ordered in. N1134

$6.98

$12.98

SAVE $7

Dust Away Aerosol Twin Pack

Gets at dust in hard to reach places without leaving residue or moisture. Great for cleaning PC keyboards and camera lenses. 2 x 150g cans. N0055

$26.98

Dick Smith Regulated AC Adaptor 5V DC 3.0A Output

Small lightweight regulated DC power adaptor with multi-plug output adaptors and selectable polarity. Accepts input voltages from 100 to 240 volts AC, with 5V DC output and current rating of 3.0A. M9914

$26.98

Dick Smith Regulated AC Adaptor 12V DC 1.5A output

Small lightweight regulated DC power adaptor with multi-plug output adaptors and selectable polarity. Accepts input voltages from 100 to 240 volts AC, with 12V DC output and current rating of 1.5A. M9915

Offers starts 21/02/11 and ends 31/03/11 or while stocks last. All offers are for retail store stock only, with strictly limited stock available. Some items may not be available for mail orders, stock movements between stores and back orders. No rainchecks. No layby. Enthusiast electronic items are not available in all stores. Offers may not be available in some reseller or franchise stores. Please contact your local store to determine availability.

dick smith

Talk to the Techxperts

Community TV station

TVS

If you watch digital TV in mainland capitals, you may have come across a "community" channel. In Sydney it's a station called TVS, which has a range of interesting programs, quite different to those on main-stream stations. So what is TVS and who are the people behind it?

In a number of ways, the operation of "free to air" television station TVS, or Television Sydney as it is properly called, is far ahead of the major free-to-air broadcasters in its takeup of digital technology. All programming, adverts, station IDs etc are digitised and merged to provide a programming stream that runs 24 hours a day, seven days a week. In the early morning hours the operation runs without human help.

TVS emanates from within the Werrington campus of the University of Western Sydney (UWS) – but it is not part of the university.

Stroll into the featureless building on campus and you enter the TVS suite of rooms. But there are no studios, no cameras, no lights, no announcer's booth and no rows of on-air monitors, cosseted by technicians.

In fact, all TVS programming is made off site. The TVS HQ is purely a digital centre which pulls all the elements together, plots the program output and then sends the output via microwave to a dish at nearby Horsley Park, then onto the Broadcast Australia transmitter at Gore Hill, near North Sydney.

by Barrie Smith

Startup

TVS commenced initial tests in November 2005 and launched an analog service in February 2006, on UHF channel 31 The digital service began on March 1 2010. Previously there had been a community broadcaster on channel 31 but that had been off air for two years, prior to the arrival of TVS.

The initial TVS board comprised a group called Educational Training Corporation, a joint venture between UWS and Metro Screen, a video training centre, plus a production group called Slice-TV.

David Hill, ex-chairman of the ABC, was the original convener of the board and then former GM of Seven Network Queensland, came in as the initial CEO. Henri de Gorter, the Program Manager, was hired from the beginning.

Right from the start, the channel was a fully digital and server-based station. This was enabled due to the co-operation with a company called Playbox, who supply automated, software-based broadcasting solutions. Playbox has its R&D centre in Sofia, Bulgaria.

Staffing

The station runs 24 hours a day, seven days a week. The permanent staff consists of de Gorter, Operations Manager Ian Sneddon plus a programming assistant, an operations assistant and a promotions producer. Added to this is the UWS-appointed CEO, Rachel Bentley.

The five full-time staff (plus the CEO) is augmented by four part-timers, who work in the evenings from 4pm as presentation coordinators. This is 'prime time', when most of the ad revenue is generated; at 10.30 or 11 at night these operators go home and the station continues running automatically.

Programs are produced off-site and supplied in a variety of formats and then fed into the servers by volunteers who come in on occasional days. This group also takes care of TVS' YouTube presence on the Web.

Audience feedback

Since going digital TVS has become available to a greater spectrum of the available audience. Previously, with analog transmission, it was found that the audience peaked at about around 1.1 million viewers a month in 2009. Since then it declined but with the advent of the digital signal, has come back to about that level. Many potential viewers are still unaware that the broadcaster has added a digital signal, on digital Channel 44.

Most current TV sets, set top boxes and PVRs do not sense the arrival of a new station unless a new scan is conducted. Also some older SD set top boxes can pick up all of the new channels, including TVS and some of the ABC channels.

Programming

Approximately 45% of TVS programming is produced in Sydney or NSW. Some programs are made by people and groups in Nowra, Bowral, Bathurst and similar places, so most producers can see their programs going to air from their home town — or they can go to the Web site and view the video stream. Another 35 per cent of programming comes from the other states.

Most of it can be summed up as "niche" programming. The automotive programs are highly popular: Four Wheel Drive, Classic Restos, Gasoline, Drive It and Cruisin'.

One of the lifestyle programs — Living on the Coast — comes from Nowra and is, in Henri de Gorter's opinion, "one off the best programs you'll ever see and every bit as good Channel Nine's GetAway but without the advertorial

TVS outputs a digital signal with a bit rate of 6.5Mbits /second using QPSK modulation.	
Power output:	Digital – 800W (ERP 3.5kW)
	Analog – 20kW (ERP 548 kW)
Digital signal:	536.625MHz (Ch29)
	[Logical Channel Number 44]
Analog signal:	548.25MHz (Ch31)

It may not look much like a TV station . . . because TVS is nothing like a "normal" TV station!

Operations Manager Ian Sneddon checks the two Playbox digital servers, each with seven Terabytes capacity, used as playout machines.

There's a wide variety of special interest and "niche" programming on TVs that the major networks wouldn't touch – ranging from foreign language/foreign interest news programs from Deutsche Welle and Al Jazeera as seen above to an extensive library of old movies, including many of the classics.

content! We can't have anything like that on a community station. The government does not allow it."

Then there's the staple fare of every community station: old movies ... Vincent Price, Bela Lugosi et al. Some years ago, one supplier delivered to TVS about 800 movies for its library. Plus there are old 50s and 60s TV series like I Love Lucy, Beverly Hillbillies and a current Sunday night favourite: One Step Beyond.

Some English language programming is derived from Al-Jazeera out of Qatar plus Deutsche Welle, the worldwide news program from Germany.

Advertising

TVS is allowed to sell up to seven minutes per hour of commercial content. Labelled 'sponsorship', every time a commercial is aired, an ID appears on the top left corner of the screen saying 'Sponsor'. The regulations state that anyone who advertises must carry this ID.

TVS does not make programs and has a licence to air its programs in NSW only. So if a producer can deal with any of the other states or overseas entities, it can do so. It's up to the producer to make a program within the guidelines and make a dollar out of it later.

No charge is made by TVS to air the program, nor is the producer able to charge for the use of its material. Any ad revenue gained from a sponsor is shared with the producer.

An interesting facet of the regulations requires TVS to show a billboard at the program's beginning, giving credit to the advertiser. So you know the show has advertising — not advertorials.

Funding

Funding mainly comes from adverts, while an ongoing effort is made to seek grants or donations from -minded people who may be able to support the channel. Initially, TVS received a grant of $600,000 to help in the digital startup. This was granted to all community broadcasters, as part of the granting of the licences from the Federal government.

Added to this, the station is "very happily supported by the University of Western Sydney, who supply a lot of 'in kind' support." As de Gorter says: "Currently we're sitting in this marvellous building here. Without them we wouldn't have a channel."

There is a community broadcast channel in every capital city except Hobart. Added to this is a number of smaller stations, in some of the country regions.

TVS is not allowed to form a network but there is an alliance, the Australian Community Television Alliance, a loose membership of the five channels.

Output

Currently the station is outputting its digital signal in

There are also some popular "golden oldies" shown such as The Beverly Hillbillies and I Love Lucy from the 1950s and 60s.

Shelf Life, hosted by Drs Milissa Deitz and Rachel Morley (UWS School of Communication Arts) deals with writers and books.

TVS carries programming that could be considered "home made" but is quite professional in style and content. Strike Zone (at left) is hosted by full-time fishing journalist Al McGlashan. Adrian's Reptile World, hosted by Adrian Hemes, is recorded in the field and shows reptile natural habitats.

16:9 format and SD resolution (920x576i). Any increase in quality will depend on government action in its run up to a full digital service in Australia and the cut off of analog in 2012. At that time there will be a re-allocation of all the frequencies when this changeover is made. The licence that TVS has at moment is current only until 2013 and allows only one service.

The signal from Gore Hill extends as far north as Gosford, west to Katoomba, and as far south as Bowral. The station would like to fill in the 'holes', as do the mainstream broadcasters, with translators at Kings Cross, North Head and the Central Coast.

"People may find that their antennas are pointing to a repeater and we have to explain that our transmission is from Gore Hill, the Broadcast Australia tower near North Sydney", de Gorter adds.

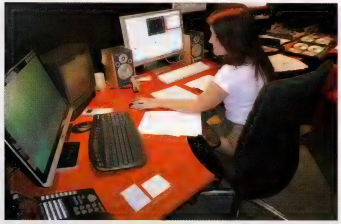
For example, in Sydney's Northern Beaches area the reception pattern is highly variable: this writer can receive only a snowy picture while, nearby, others (including editor Leo Simpson) pick it up very clearly. All antennas in these examples are pointed south towards the North Head repeater and all receive the station as an analog signal from Gore Hill. Another staff member, only 1km away but with an antenna aimed towards the Central Coast, cannot receive TVS at all.

However, the reality is that not much will happen until analog is closed down (planned for 2013) and frequencies reallocated. TVS needs it to increase its audience: "We're a Sydney station and we should have the same reach as everyone else", de Gorter stresses.

Future plans

The biggest push for TVS is to be competitive in the broadcast television world and to generally improve the quality of the programs. The station does not want to change the content. As de Gorter says "The eclectic mix of programs we have is what makes us popular. If we went down the path of sanitising our programs, then people would stop watching us.

Unlike the other channels where they have a budget and buy programs from distributors, we're pretty much



Two edit suites run G5 Macs and use Final Cut Pro software to edit station promotional clips.

TVS ingests the media — tape or DVD —and encodes it to MPEG.

reliant on what comes in the door — and we work with our producers.

"So we get all sorts of programs. What we would like to see is that, while we don't want to change the content, we'd like to see it presented 16:9 wide screen with good audio and reasonable lighting. Later on we would like to do outside broadcasts.

For his part, Ian Sneddon is working very hard to get more paths in and out of the station: "We only have one path out of here so we need another path. Plus we need an incoming path.

Program assembly

The whole area occupied by TVS would be roughly that of a suburban house, in a series of connecting rooms. One room, barely larger than the average living room, houses a series of desktop stations.

TVS uses a program called CaptureBox to accept the media — tape or DVD — and encode it to MPEG. These files are then loaded onto the server. Most of the Beta formats, such as Betacam, Digi Beta etc can be handled, but not Betamax Most of the material TVS receives is on Mini DV cassettes, a consumer format.

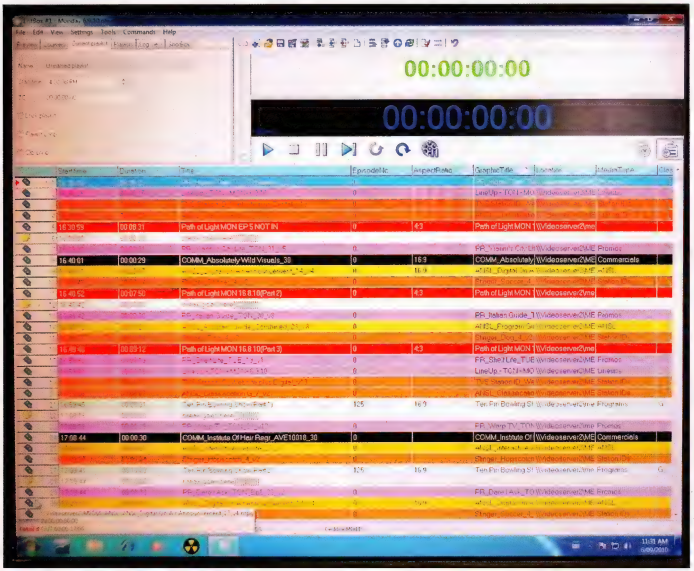
As Ian Sneddon explains: "This is where we insert all the in and out points as data, stored along with the programming. When the programrs make up their list they know the running times of the programming, ads etc. At 4.30 each afternoon the list runs out and the next day's list is loaded up."

The equipment room houses two Playbox digital servers, each with seven Terabytes capacity and used as playout machines. The output leaves as a Serial Digital Interface (SDI), passes through an MPEG encoder, sent to the microwave link at Horsley Park and then on to Gore Hill.

The Web presence relies on Apple Xserve servers to host the TVS Web and the program Web streaming. TVS was the first FTA station in the country to stream its signal live and can only do so because it owns Internet rights to its programs. Most commercial stations cannot do that because they don't have streaming rights.

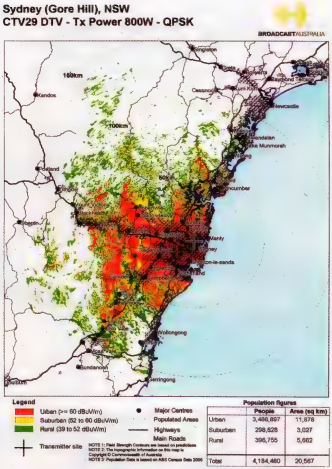
Further along a hallway are two edit suites, running G5 Macs and using Final Cut Pro software. These are used for editing station promotional clips.

Rounding out the tech side for the operation is a 50kVA



Data display of all the in and out points of programming.This list is made up each day and triggers the playout.

Sydney (Gore Hill), NSW
CTV29 DTV - Tx Power 800W - QPSK



Population figures

	People	Area (sq km)
Urban	3,466,897	11,878
Suburban	298,828	3,027
Rural	396,755	5,662
Total	4,164,480	20,567

Left: the theoretical TVS signal strength across the Sydney area. Due to Sydney's hilly topography, some areas are marginal at best and others have no reception at all.

generator, ensuring an Uninterrupted Power Supply (UPS). As Sneddon says: "If we lose power you won't notice anything, other than the lights will go down momentarily because they're not on UPS. Then you hear the noise of the generator starting up. We can run for probably up to an hour."

There is no booth announcer. All voice overs are pre-recorded. At the Gore Hill transmitter an audio loop runs music when a server goes down.

Hiccups

Sneddon explains that, "if there are problems, generally I will get a call from the people who run the transmitter.

"The system is very reliable. The guy who put it together, Les Fisher, from Digital Space Media, did a fantastic job and we work with the software people to develop it further. There is inbuilt redundancy but problems can still happen …

"I remember about a month ago I got a phone call while I was having coffee in Balmain. It was the transmitter at Gore Hill and they said we had gone off air — one of our servers had failed. So with my iPhone I used an app to get into the desktop at UWS to switch to the other server and get us back on air.

"Most stations are manned when they're on air and there is always someone watching. But we don't have that. So we use other ways." *sc*

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Presenting:

The Maximite

Part 1 – by Geoff Graham

There's on often-quoted cliché in advertising which says "its use is limited only by your imagination . . ." Well, here is a project that goes way beyond your imagination because you, like us, will have only scratched the surface of uses. We're pretty proud of this one: a powerful but very economical microcomputer which has so much potential that you will probably think of uses we haven't even dreamed of!

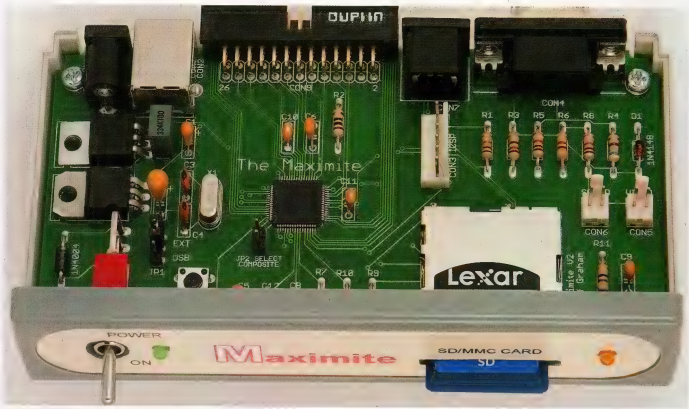
Remember the very early days of personal computers when the most common answer to "but what can it do?" was "oh, it can store recipes and track you household finances". It was pretty lame back then, especially when personal computers cost up to ten thousand dollars.

But The Maximite can do that. Or it can detect intruders. Or measure voltages. Or sense water levels. Or log phone numbers. Or teach children computers and programming. Or . . . OK, you get the picture, we're sure.

Of course, that's only half the story. It can also act on those inputs and do something, such as turn on lights or video recorders. Irrigate a field or greenhouse. Dial a phone number and play a message. Control a website. Launch a first-strike nuclear missile. . .

If you think we're being a bit over the top, we are. However, the simple truth is, with appropriate programming (and what better way to learn than with the Maximite!) this powerful little micro CAN do all of those things and just about anything else you can think of.

We're extremely confident that the Maximite will spawn its own army



Inside The Maximite case. There's not a great deal to it as all of the "smarts" is in that PIC32 chip in the centre. Also seen in this shot is the memory card slot on the front panel which can be used to drive The Maximite or to save data.

of users and supporters, along with Maximite software, simply because it is so versatile and so simple to build. Best of all, it's cheap to build – almost bubble-gum cheap!

So what is the Maximite?

Elsewhere in this issue we described the incredible new Microchip PIC32 processor. . . and now we put it to practical use. It is the heart of the Maximite – a complete computer based on a single chip.

On the one hand it is a full-featured micro computer with keyboard input and a video output with extensive graphics capabilities to a TV or VGA monitor. It runs a powerful BASIC interpreter and can save and load programs and data to and from a low-cost SD memory card.

At the same time it has 20 I/O (input/output) lines that can be a mix of analog inputs or digital input/outputs.

You can measure voltages, temperatures, frequency and record the data to the SD card, all under program control. You can also detect switch or contact closure and respond by activating relays, turning on lights or whatever.

You can connect it to a larger computer via USB and upload or download programs and data. You can also pop the SD card out and read the data on your desktop computer where you can load it into a spreadsheet such as Excel for further analysis.

The Maximite will automatically load and run programs from the SD card so you can use it as a stand-alone computer without keyboard or video display. But, if you do connect a video display, you can display readings, draw graphs or do whatever you need to do to display data for your application.

Finally, all inputs and outputs are optional. You can ignore the external monitoring and control function and use it as a general purpose computer to balance your cheque book (or similar) or you could ignore the keyboard and video facilities and use it as a dedicated embedded computer or controller.

Putting It to Use

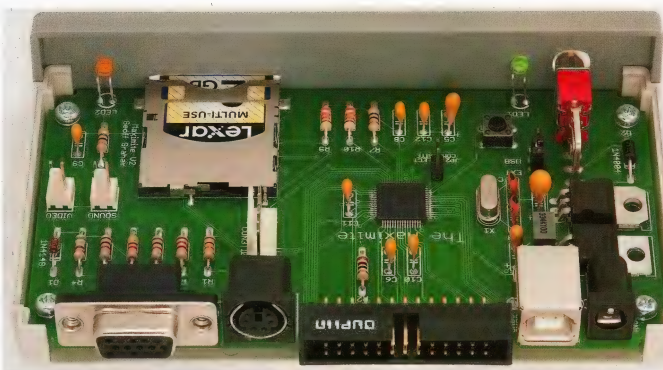
On one level you can consider the Maximite to be a modern incarnation of the Tandy TRS-80 or Commodore 64 computers of yesterday. Using it like this The Maximite will take you on a nostalgic trip into the days where computers were much simpler.

You just plug the Maximite into a 9V power source and you will be immediately presented with the BASIC interpreter's prompt. You can then experiment with various commands or type in a program and save it to the SD memory card.

The BASIC language, which is an acronym for Beginner's All-purpose Symbolic Instruc-

At a glance . . .

Processor:	PIC32MX795F512H-80I/PT (or PIC32MX695F512H-80I/PT)
Clock speed:	80MHz
RAM:	128K (internal)
Software:	MMBasic (similar to Microsoft BASIC)
I/O	20, individually configurable
Video output:	Monochrome standard VGA or composite video
Audio:	500mV for amplifier, sound card, etc, or hi-z speaker
Interfaces:	SD, MMC or SDHC card; USB 2.0 and IBM keyboard
Power supply:	9V DC @ ~150mA
Size & weight:	155 x 92 x 29mm; 150g



From the rear (again with lid removed) this shot shows the VGA and keyboard sockets, multi-way I/O connector (black) and at the right, the USB and DC power sockets.

tion Code, is a standard in the computer industry and was designed to be very easy to learn. So this provides an excellent way to get into programming.

Maximite BASIC is also largely compatible with Microsoft BASIC so there are many programs on the Internet that you can load and run (some may possibly need a few modifications but that's not too unusual with downloaded programs!).

While being easy to use, Maximite BASIC is also very powerful. It uses floating point for numbers, has long variable names, extensive string handling, file input/output and multidimensional arrays of numbers and strings.

With its 128KB of RAM the interpreter can handle programs of up to 1000 lines and thanks to the fast PIC32 chip it will run through your program at speeds up to 30,000 lines per second.

If all this sounds like double-Dutch to you, then you are a perfect Maximite candidate. Build one and learn!

Apart from this, the great strength of the Maximite is its ability to interact with the external world. On the back panel are 20 input/output signal lines which can be used to monitor and control most things with electrical inputs and outputs.

The Maximite could form the centre of an intelligent burglar alarm, a flexible oven controller or a data logging system monitoring the operation of your car's engine. It could control the climate in a greenhouse by opening panels and turning on fans and irrigation systems in response to temperature, humidity and sunlight.

Because it is so inexpensive the Maximite can be used for quite simple projects – for example, a smart battery charger/monitor or simply controlling a fan or pump.

At this level it can be thought of as something like a PICAXE chip on steroids.

Educational tool

The Maximite will also make a great educational tool. Its simplicity and ease of use make it ideal for young students who need to get something happening within a short time. They can plug it in and within seconds be experimenting with a programming language.

And with SD card storage they can then take their creation away to be continued on another day. Old timers who did indeed "cut their teeth" on the TRS-80 and Commodore 64 etc, will remember with horror the power failures which lost perhaps days of programming because then, there was no such things as "easy" storage. Floppy disks (what are they?) were around but incredibly expensive and hard disks were still only a twinkle in their creator's eyes!

Back to the Maximite: by attaching a few external components, students can also interact with physical objects beyond the keyboard and video display.

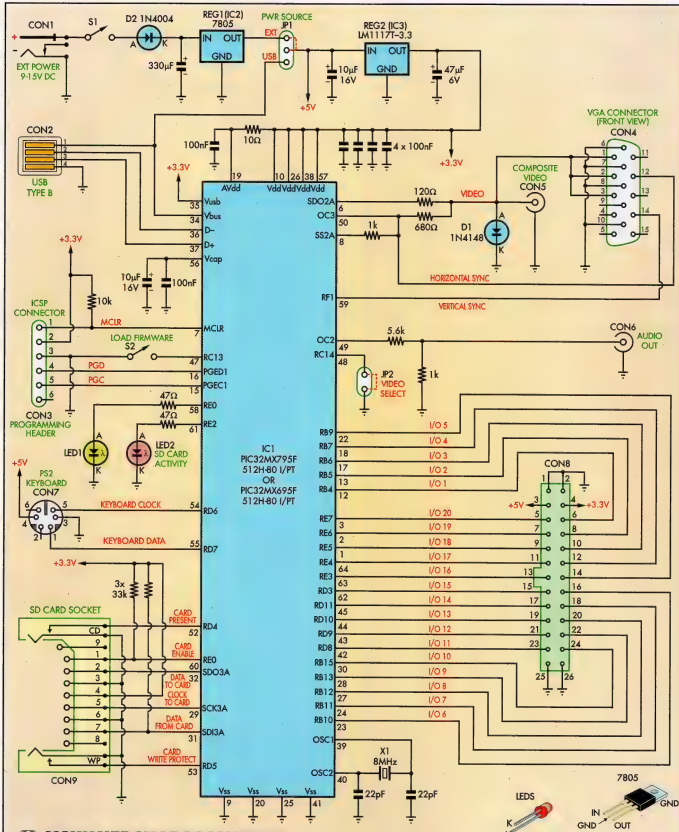
For example, it would be easy for a student to connect up a temperature sensor and a fan and write a simple program to turn on the fan at a certain temperature.

Just imagine: light a match under the sensor. . . and the fan would come on and blow out the match! Magic? No. Maximite!

Video output

The video interface on the Maximite will generate either a standard computer VGA signal or a composite video signal for use with a TV set. The VGA connector is mounted on the PC board and is available on the back panel of the Maximite's box while the composite video is available as a pair of header pins that can be wired to a panel mounting RCA socket.

The VGA output uses the standard scanning frequencies of 31.5kHz horizontal and 60Hz vertical and should work with any monitor, no matter how old. The output is scaled for a 4:3 aspect ratio and most people will have an old one of these monitors lying unloved in a cupboard since whiz-bang LCD monitors came out (it will also display on an LCD monitor!). The character set



MAXIMITE MICROCOMPUTER

Fig.1: we said The Maximite was pretty simple and this complete circuit diagram proves it. Just about everything you need in a microcomputer is integrated into the one mighty chip, the PIC32 (see article elsewhere in this issue).

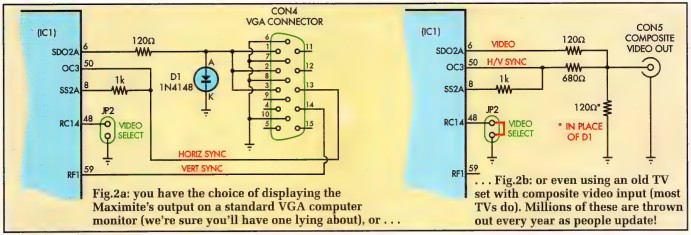


Fig.2a: you have the choice of displaying the Maximite's output on a standard VGA computer monitor (we're sure you'll have one lying about), or . . .

. . . Fig.2b: or even using an old TV set with composite video input (most TVs do). Millions of these are thrown out every year as people update!

includes the full upper and lowercase set with 80 characters per line and 36 lines per screen.

The composite video output is a standard 625-line, 50Hz signal suitable for use on any TV set or monitor that will accept a PAL input (ie, any TV set used in Australia, New Zealand, the UK and many other parts of the world). It also has the full character set but displays 50 characters per line with 18 lines per screen.

A jumper on the PC board will switch between VGA and composite. This jumper is detected at power up and the timing of the video system is configured accordingly. You could, if you wished, use a switch to select the type of display at power up.

Both outputs are monochrome and have graphics capability. Under control of your BASIC program you can turn on and off any pixel, draw lines, circles, and boxes, and place text anywhere on the screen. Note that because the Maximite's pixels are not exactly square the circle will be more of an oval.

There are many cheap VGA and composite monitors now available (especially on eBay) with screen sizes of 5 to 7 inches. These are intended for use in cars but they also make an excellent display when you are using the Maximite as an embedded controller. For example, if you have built an intelligent irrigation controller based on the Maximite you could include a screen that would show a graph of the rainfall, temperatures and the amount of irrigation delivered.

The remarkable aspect of the video signal is that it is generated entirely in the PIC32 using nothing but the standard peripherals integrated inside the chip. The method used is based on a technique described by Lucio Di Jasio in his book "Programming 32 bit microcontrollers in C". It uses a DMA (Direct Memory Access) controller to transfer the pixel data from memory to an SPI (Serial Peripheral Interface) controller which then clocks out the video with the required timing. The output is sharp and rock solid: you could not get better even if you were using a dedicated VGA controller.

Other than servicing an interrupt this method entirely bypasses the PIC32 CPU which only has to write the pixel data to a defined part of memory and it will then magically appear on the video monitor. This leaves the CPU free to run at full speed interpreting the user's BASIC program.

Keyboard and USB

The keyboard interface is quite straightforward. You can plug in a standard IBM PS2 compatible keyboard with a 6-pin MINI DIN connector and anything you will type will go straight to the BASIC interpreter. All the standard keys will work including the numeric keypad, shift and caps lock.

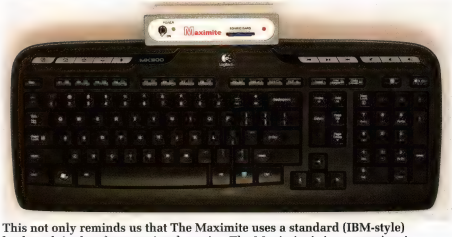
The USB interface emulates a serial COM connection over USB. This means that you can open a serial emulator on your computer and anything you type will be received by the Maximite, just as if it was typed on the keyboard.

Both USB and the keyboard will operate simultaneously and in parallel. This allows you to have both of them connected and anything typed on either one will be received as if from a single stream.

Similarly, any output from the BASIC interpreter will be sent out over the USB interface as well as the video interface, although graphic output (lines, circles etc) will only be displayed on the video output. You can plug in or unplug the keyboard, video and USB at any time and it will not affect a running program.

The USB interface provides an easy way to enter and run programs without having to connect a monitor. Using this interface you can even edit your program on your PC (using something like notepad) then copy it via the USB interface into the Maximite's memory for testing.

The USB interface is handy in another couple of cases. Firstly, it makes it possible to build a stand alone controller (such as the irrigation controller



This not only reminds us that The Maximite uses a standard (IBM-style) keyboard, it also shows us just how tiny The Maximite is in comparison!

proposed earlier) and using the USB interface you can plug in a laptop and download history or other data from the BASIC program running on the Maximite.

Secondly, the USB interface allows the Maximite to act as a peripheral to a desktop computer running Windows or a similar operating system. A simple program running on the Maximite could measure a series of voltage and digital inputs and send the values over the USB interface. A program running on the larger computer would see a series of readings and could interpret them and take action as required.

The communication could also be two way, certain codes arriving from the USB interface could be a signal to the program running on the Maximite to change the state of its digital outputs. This allows you to easily control external electrical systems from a desktop computer, something normally not easy to do.

The USB interface also has one more function. It will enable you to update or "re-flash" the firmware running on the PIC32 by uploading the new firmware from your Windows computer. With something as complex as the Maximite there are bound to be some undiscovered bugs lurking in there and this feature will allow you to load the latest and greatest firmware version, even though your chip is firmly soldered to the PC board.

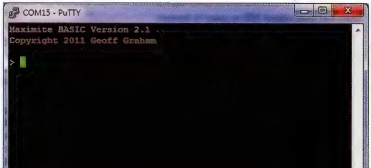
Maximite BASIC

Arguably the core of the Maximite is the BASIC interpreter (called MMBasic) which was specially written for the Maximite.

It is a full implementation of the BASIC language with over 120 commands, functions and operators. Because of its size we can only provide a brief overview here however the SILICON CHIP website has the "Maximite User Manual" available for download and that provides much more detail.

All numbers within MMBasic are saved and manipulated as floating point values. Floating point is similar to how a scientific calculator handles numbers and allows you to multiply, divide and use mathematical functions without accidently creating nonsense results.

MMBasic is also proficient at handling strings of characters which you can join and pull apart in various ways. Variables in MMBasic can be either a number or a string and a variable name



MMBasic, specially written for the Maximite, should be familiar to anyone who has ever used used BASIC as it is a full implementation of that language.

can be up to 32 characters long. You can also define arrays of numbers and strings with up to eight dimensions.

In addition to the Microsoft BASIC constructs MMBasic implements a number of modern programming structures documented in the ANSI Standard for Full BASIC (X3.113-1987). These include the DO WHILE ... LOOP and the structured IF .. THEN ... ELSE ... ENDIF statements. These newer constructs make it easier to write programs that have fewer bugs and are easier for others to understand.

MMBasic has a number of special commands and functions for dealing with the external I/O pins on the Maximite. Using the SETPIN command you can set an input as an analog (ie, voltage) input, as a counting input or as a digital input/output. The PIN() function will return the value of an input and the PIN()= statement will set an output.

For example, the following fragment of code will set an output (eg, an alarm) high if an input voltage strays outside of the range of 2V ±0.5V.

```
SETPIN 1, 1          ' pin 1 is input
SETPIN 2, 8          ' pin 2 is output
V = PIN(1)           ' get the voltage
IF V < 1.5 OR V > 2.5 THEN
PIN(2) = 1           ' output high
ENDIF
```

The apostrophe (') starts a comment and everything after it on that line is ignored.

You can also set up to 20 interrupts on either the rising or falling edge of a signal at the input pins. When an interrupt event occurs the program will branch to a section of code specific to that interrupt and return to the main program when finished. This makes it much easier to handle intermittent events such as when a button has been pressed.

For timing you can set an interrupt to occur every so many milliseconds, you can also time events using the TIMER function which returns the number of milliseconds since it was reset and for general timing you can halt the program's execution for a number of milliseconds using the PAUSE command.

MMBasic runs at about 30,000 lines per second, although that will vary considerably depending on the type of statements being executed. Regardless it allows your programs to respond quickly to external events, typically in less than a millisecond. This means that you can monitor and react to most electrical and mechanical events, such as ignition pulses in a high speed engine and still get useful work done.

External Input/Output

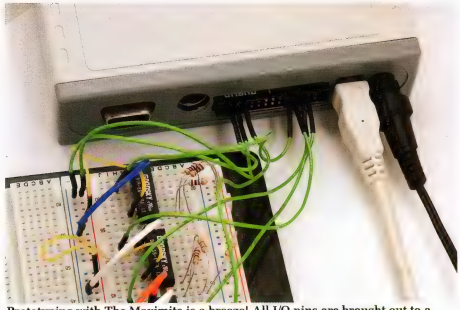
We have touched on the external input/output capabilities a number of times but it is worth going into some detail as that is where much of the Maximite's utility comes from.

Firstly all 20 external input/output pins can be configured as digital inputs or outputs. As a digital input anything above 2.5V will return true (or the number 1) and anything below 0.65V will return false (number 0). The maximum input voltage is 3.3V and for inputs above that a couple of resistors are all that is required to drop the voltage.

All inputs are Schmitt Trigger buffered so that they will switch cleanly if the input voltage is in the range between the high and low input levels.

When configured as an output, a pin will source or sink 10mA to 18mA, depending on the required drive voltage on the output pin. This is enough to drive a LED or a reed relay and heavier loads via a transistor buffer. In future we will describe a circuit for this and other aspects of input/output buffering.

Pins 11 to 20 have the special capa-



Prototyping with The Maximite is a breeze! All I/O pins are brought out to a multi-way connector on the rear panel. Standard patch leads can therefore be used. Added to that is the ease of connection to a standard PC and voila!

bility of working with 5V circuits. They will tolerate 5V as an input and can be configured as open collector outputs to drive 5V circuits.

Pins 1 to 10 can be configured as analog inputs and will measure and return the precise voltage at the input in the range of 0V to 3.3V. For inputs higher than this a simple voltage divider can be used.

The accuracy of the measurement is mostly dependent on the accuracy of the 3.3V supply to the PIC32 but the specified regulator has a tolerance of ±1% so it will be reasonably accurate. By calibrating the reading within your BASIC program you can achieve an accuracy far better than that.

This is like having a ten-channel digital voltmeter and with the addition of suitable input circuitry, these inputs and be used to measure voltage, current, temperature, acceleration, pressure and more.

The firmware also implements a simple form of noise reduction when making voltage measurements. Ten readings are taken (over 10µs) and the two highest and lowest readings are discarded before averaging the remaining six readings to give the final value.

In addition to being normal digital inputs pins 11 to 14 can be configured to measure frequency, period or just count the number of cycles of the input. Frequency measurement can be up to 200kHz and the returned value will have a resolution of 1Hz.

When measuring period, the value will be returned as the number of milliseconds between cycles. When set as a counting input, the value returned will be the number of low to high transitions on the input since the counter was last reset.

The counting inputs can react to very fast signals on their input (less than 10ns) and operate independently of the main program (ie, they do not slow it down or hinder its operation).

Memory card

The memory card facility allows you to save programs and data and reload them later. MMBasic will work with MMC, SD or SDHC cards formatted as FAT16 or FAT32 and with a capacity of up to the maximum that you can buy (which is currently 32GB).

The file system and file format is fully compatible with Windows, Macintosh and Linux computers so you can pop the card into your desktop computer to access the data recorded on it.

Commands within MMBasic allow you to create or delete files, navigate through sub directories, save programs and load and run a program. When saving data to an SD card the WRITE command makes it easy to save the data in an Excel spreadsheet compatible format for later analysis.

Typically the Maximite can measure a voltage and save the value to the SD card in under a millisecond. In a real life scenario that means that you should be able to log data from all 10 analog inputs and save it to the SD card 50 times a second, while still doing other work like scaling the data and checking for alarms. And, with a cheap 2GB SD card, you will be able to sustain that speed for over 100 hours before you run out of space; not bad at all.

When power is applied to the Maximite the first thing it will do is check to see if an SD card is installed and, if it is, look for a program in the root directory with the special name of AUTORUN.BAS. If that file is found it will be loaded and the program will be automatically run without prompting from the keyboard (which does not have to be connected). This allows the Maximite to be used as an embedded controller without an attached keyboard or video display.

Audio

The Maximite also has the facility to generate an audio output. This is not a musical facility but it is enough to generate a sequence of attention getting tones. The sound output is made available on a 2-pin header on the PC board which can be wired to a panel mounting connector.

The sound command in MMBasic generates a square wave and, under program control, you can specify the frequency (from 20Hz to 5KHz) and the duration (in milliseconds). The tone is generated as a background task and will not delay the program which will continue running after initiating the sound.

Low power requirements

The power supply for the Maximite can come from the USB interface or an external 9V DC plugpack. With some restrictions (due to heat dissipation) the power supply voltage can range up to 15V. This means that the Maximite can also be powered from a car battery in automotive applications, for example, monitoring and logging data related to the vehicle's engine and sensors.

The current draw is about 140mA but this will increase if you are using the digital outputs to source current. With this operating current it is possible to power the Maximite from batteries during a power interruption.

For example, six AA rechargeable batteries could keep the Maximite running for 7 to 10 hours; enough to survive a typical blackout.

Circuit Details

The circuit diagram of the Maximite

is shown in Fig.1. The amazing thing about this is that everything we have been discussing, the VGA controller, keyboard input, computer running BASIC, voltage measurement, etc is accomplished with just one chip. That is a high level of integration.

At the top right hand section of the diagram is the video output. The components and values shown in Fig 1 are chosen to allow you to switch between VGA and composite video output. This involves some compromises, in the case of VGA the black level is not truly black and for composite the white level is not as bright as it could be.

However the resulting video is perfectly acceptable and can be corrected by adjusting the monitor to suit.

If you want a perfect picture all the time you can permanently configure the video for either of the standards as shown in Fig 2a and 2b.

Fig.2a shows the circuit for VGA output only. In this setup the horizontal and vertical synchronisation pulses are generated separately and are wired direct to the output connector. The video signal is generated on pin 6 and is clamped to approx 0.7V by R3 and D1. It is then connected in parallel to the red, blue and green inputs of the monitor on CON4 creating a monochrome image.

Fig.2b shows the video circuitry when it is setup for composite output. In this configuration both the horizontal and vertical sync pulses are generated on pin 50 of the PIC32 and are mixed with the video from pin 6 to create the composite video signal across the 120Ω resistor installed at D1.

When a 50Ω composite input is connected to CON5 the output voltage will be the standard 0.5V peak to peak.

The 1kΩ resistor connected to pin 8 is used in both configurations and is one of the most important features of the video controller. This feeds the horizontal sync pulse back to the SPI interface of the PIC32.

This signal is used by hardware in the SPI interface to trigger the start of the video stream relative to the horizontal sync pulse and eliminates timing variations that would occur if the video stream was triggered via the firmware alone. The result is that the video output is rock solid, something that is not easy to accomplish in a microcontroller that has a lot of other duties in addition to generating a video output.

On power up the firmware will check JP2 and accordingly configure the timing for VGA or composite. This jumper is connected to pin 48 on the PIC32 which has its internal pull-up resistor enabled. If JP2 is open the voltage on pin 48 will be high and VGA selected. If a jumper is placed on JP2 the voltage will be low and composite timing will be selected.

Sound Output

Returning to Fig 1, pin 49 of the PIC32 is the sound output. This signal is reduced to 0.5V peak to peak by a 5.6kΩ and 1kΩ resistive divider to make it suitable for a normal amplifier's auxiliary input (for example, the input to amplified speakers).

You can also drive a high impedance speaker or transducer directly with this output and in that case you would omit the 1kΩ resistor and replace the 5.6kΩ with a wire link.

CON8 provides access to the external input/output pins that are supported by the Maximite. PINs 1 to 10 are connected to I/O ports on the PIC32 that can be switched to analog inputs while PINs 11 to 20 are connected to I/O ports capable of working with 5V circuits.

The 8MHz crystal connected to pins 39 and 40 is used to generate the main clock for the chip. It is divided by 2 inside the PIC32 then multiplied by 20 to give the 80MHz CPU clock. This is further divided by 2 to give the peripheral clock of 40MHz.

Continuing in a clockwise direction around the PIC32 in Fig 1, the memory card interface uses a total of seven input/output signals.

The firmware running on the PIC32 communicates with the card via the SPI (Serial Peripheral Interface) mode which is supported by all MMC/SD/SDHC cards. This standard requires four signal lines (card enable, data in, data out and clock) with two of them pulled high by the 33kΩ resistors.

The card detect and write protect signals are generated by contact closures in the card holder and are pulled high by resistors integrated in the PIC32.

An IBM compatible keyboard is connected directly to pins 54 and 55 of the PIC32. The IBM standard requires that a pull-up resistor is used to hold the signal lines high when they are not being used. These resistors are integrated in the PIC32 and enabled by the firmware.

Indicator LEDs

Pin 61 of the PIC32 is used to drive the memory card activity LED. The firmware pulls that pin high when it is reading or writing from the card. Pin 58 drives the front panel LED which is normally illuminated but can be turned off or on under control of the BASIC program. When you are loading a new version of the firmware via USB this LED will flash to show that the device is in the boot-load mode and is ready for the firmware to be uploaded.

The PIC32 can also be reprogrammed via CON3 which will accept an ICSP programmer/debugger like the PICKit 3. Normally you would only use this feature if you were developing and testing a new version of the firmware.

Pin 47 on the PIC32 is another pin that is pulled up to 3.3V by an internal resistor and is used to detect if the boot-load button is pressed. This is checked on power up and is used to enable firmware updates via USB.

Last on our tour around the PIC32 is the USB interface. This is quite straightforward, pin 35 is the 3.3V supply for the USB transceiver integrated into the chip while pins 36 and 37 are the data lines. The firmware can tell if the USB is connected to a host by monitoring the voltage on pin 34.

There are two power supplies, +5V provided by REG1 (7805) and +3.3V from REG2 (LM117T-3.3). Jumper JP1 allows you to power the Maximite from the USB 5V supply provided by the host if that suits your requirements.

The keyboard is the only component that requires a 5V supply and is one of the main reasons REG1 is present. REG2 (the 3.3V regulator) is also supplied by REG1 and this means that its output voltage is very steady over a wide range of input voltages. This provides a stable reference for the ADC (Analog to Digital Converter) resulting in consistent voltage measurements.

The schematic shows a number of capacitors on REG2's output. These are decoupling capacitors situated near the power supply pins on IC1 and are critical in providing glitch- free power for the chip.

Next month: construction!

So that is the Maximite. As there is so much information to digest in one sitting, we'll leave the construction details to next month.

In the meantime, gather the components you need – you'll find it easiest with the kit from Altronics (Cat K-9550) – and get ready to start your Maximite micro computer together. SC

Universal voltage regulator

By NICHOLAS VINEN

For any time you need low-voltage regulated supply rails

MOST PROJECTS REQUIRE some form of voltage regulator. The Universal Power Supply project from August 1988 has been so popular, the kit is still on sale some 23 years later!

Basically, that design allowed you to build one of four different voltage regulator configurations on a single PC board. It could be configured in both split (positive & negative) rail and single rail versions and could be used with a variety of power transformers, with or without centre-taps. It could also be set up for a variety of output voltages, depending on the regulator(s) used.

In view of its popularity, we thought it was time to make some improvements. Accordingly, we have made the following tweaks to improve the original design:

(1) Designed a smaller PC board;
(2) Added terminal blocks for inputs and outputs;
(3) Made it easier to build;
(4) Made better provision for regulator heatsinks;
(5) Added LED indicators/bleeders for both rails;
(6) Added reverse-biased diodes at the output for regulator protection; and
(7) Made provision for a wider range of electrolytic capacitor sizes.

Universal regulator

This project is called a "Universal Regulator" because it's so flexible. Most commonly, it will be used to convert the AC output from a transformer (or an AC plugpack) to a regulated DC output. It can also be used to regulate an unregulated DC input voltage or it can be used to step-down a DC input voltage to a lower (regulated) output voltage.

As with the original design, the unit can be built in both dual-rail and single-rail versions. The output voltages can range from ±5V to ±24V at currents of up to 1A per rail. It all depends on the transformer and the regulators used.

Because this board can generate split (ie, positive and negative) rails, it is ideal for powering op amp circuits. It is also very handy for circuits which only require a positive supply (eg, +12V), in which case some components can be omitted.

Transformer labelling

Before going further, let's take a closer look at how transformers are marked. Sometimes you will see a transformer labelled as "9 + 9" or "2 x 9". This usually means that it has two 9V separate windings which can be connected in series or parallel. If you connect them in series, you have an 18V transformer with a centre tap.

If you connect them in parallel and in phase, you have a 9V transformer with twice the current rating of the centre-tap configuration (if they are in anti-phase, you will get no output).

A "9-0-9" label implies two 9V secondary windings with a fixed centre tap. These can *not* be connected in parallel because they will be in anti-phase and so there will be no output.

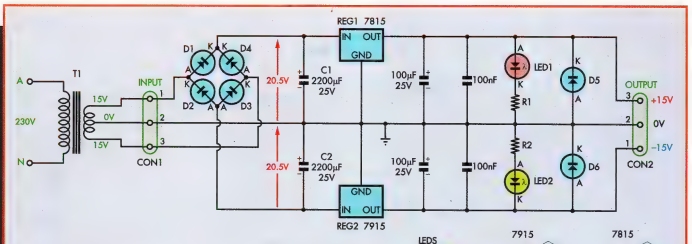
If a transformer has a VA rating (and most do), you can calculate the maximum theoretical output current by dividing the secondary voltage into that figure. So for example, a 60VA transformer can provide 2A if its secondary is 30V (60 ÷ 30) or 5A if its secondary is 12V (60 ÷ 12). Some transformers have multiple secondary taps so you can select the best combination for your circuit.

Different configurations

As with the previous design, the PC board can be built in any of four different configurations according to which parts are installed. The circuit diagrams for these configurations are shown in Figs.1-4.

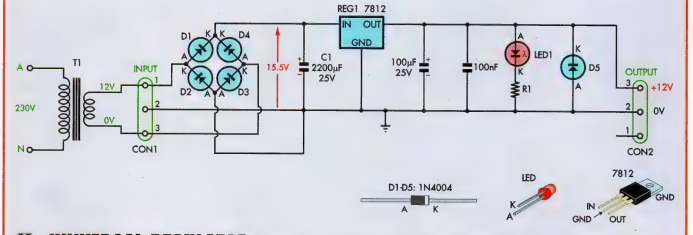
To generate split rails (eg, ±15V), it is a good idea to use a centre-tap configuration, as shown in Fig.1. The transformer secondary windings are connected to a bridge rectifier with the centre tap to ground. The peak rectified DC voltage is the transformer secondary voltage multiplied by 1.414, minus one diode drop (about 0.7V).

In the example shown, a 15V-0-15V transformer results in about 20.5V across each filter capacitor, which is then regulated to ±15V using 7815 and 7915 3-terminal regulators (REG1 & REG2). The average filtered voltage will probably be slightly higher than this for light loads on the outputs and lower under heavy load. In this



SC 02011 **UNIVERSAL REGULATOR** TAPPED TRANSFORMER SECONDARY, DUAL OUTPUT CONFIGURATION

Fig.1: the circuit for use with a centre-tapped transformer to generate split rails. Diodes D1-D4 form a bridge rectifier, while capacitors C1 & C2 filter the rectified AC. Regulators REG1 & REG2 provide a steady output voltage while LED1 and LED2 indicate operation. Different output voltages are obtained by changing the transformer and regulators.



SC 02011 **UNIVERSAL REGULATOR** UNTAPPED TRANSFORMER SECONDARY, SINGLE OUTPUT CONFIGURATION

Fig.2: this version of the circuit is used to derive a single, positive output voltage from a transformer with no centre tap. As in Fig.1, it uses a bridge rectifier but in this case ground is connected to its negative end and the negative regulator components are omitted.

configuration, each filter capacitor is charged at twice the mains frequency (ie, at 100Hz).

Note that while the circuit diagrams show a specific transformer and regulator combination, along with the expected filtered DC voltage, these are just examples and other combinations can also be used, as explained later.

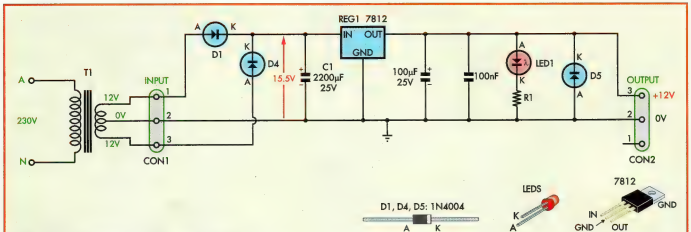
If a negative output voltage is not required, the centre-tap configuration is no longer necessary. Fig.2 also uses a bridge rectifier for full-wave rectification but the components for the negative output are removed. There is no centre tap connection from the transformer but otherwise the circuit is identical to that of Fig.1.

It is also possible to derive a positive single-rail output using a transformer with a centre tap – see Fig.3. In this case, only two rectifier diodes are needed. Note that the rectified output voltage is a little over half that which would be achieved by using the same transformer in the circuit of Fig.2 and ignoring the centre tap (ie, leaving the centre tap disconnected).

Finally, in Fig.4, we show how it is possible to derive split rails from a transformer with no centre tap. This circuit is mainly used with AC plugpacks as they generally lack a centre-tap connection. The diodes are arranged to form a full-wave voltage doubler, which essentially consists of two half-wave rectifiers with opposite polarity.

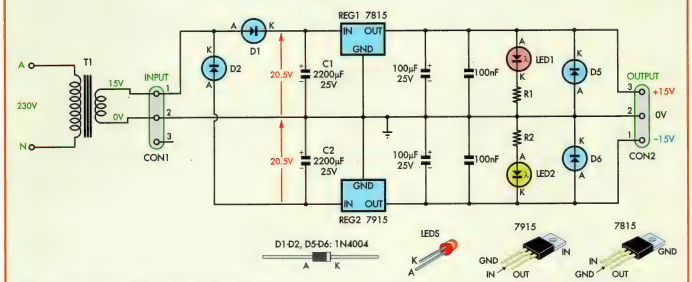
Because of this alternating half-wave rectification, the filter capacitors (C1 & C2) are each charged at 50Hz. This means that the ripple voltage on C1 and C2 is roughly twice that of the circuit shown in Fig.1. As a result, the ripple current through the capacitors is also doubled and that means that less current is available (see Fig.6).

However, it is still possible to get a



UNIVERSAL REGULATOR TAPPED TRANSFORMER SECONDARY, SINGLE OUTPUT CONFIGURATION

Fig.3: as with Fig.2 this version is used when a single, positive output voltage is required but this time the transformer has a centre tap. As a result, only two diodes (D1 & D4) are required to form a full-wave rectifier.



UNIVERSAL REGULATOR UNTAPPED TRANSFORMER SECONDARY, DUAL OUTPUT CONFIGURATION

Fig.4: this version allows a split rail output to be derived from a transformer without a centre tap. This circuit is often used with AC plugpacks, with diodes D1 & D2 used as a full-wave voltage doubler. The circuit of Fig.1 is preferred for use with chassis-mount transformers.

full 1A output using this configuration, depending on the particular transformer and output voltage combination.

Obtaining other voltages

Note that it is possible to use the circuit shown in Fig.4 to generate a single output voltage which is twice that of the circuit shown in Fig.2. This is achieved by using pin 1 of the output connector as ground for the load. The voltage across pins 1 & 3 is then double the usual output voltage. That is why the circuit is known as a "voltage doubler".

As mentioned, the centre tap of a transformer may be ignored and the transformer is then treated as having a single secondary winding with a voltage that is the sum of the two individual windings. This means that you can derive three different positive DC voltages from a centre-tapped transformer: about 1.4 times the secondary voltage (as shown in Fig.2), half that figure (as shown in Fig.3) or twice that figure (as shown in Fig.4).

Dual-output configuration

Now that we have had a look at the various circuit configurations, let's take a closer look at how they work.

Fig.1 shows a dual-output (±15V) configuration based on a centre-tapped transformer, a bridge rectifier (D1-D4) and a couple of 3-terminal regulators. As shown, a 15V AC sinewave is applied to pin 1 of CON1 by the transformer. At the same time an identical sinewave is applied to pin 3 but is 180° out of phase.

In other words, the voltage at pin 3 is inverted compared to the voltage at pin 1.

When the voltage at pin 1 is rising, the voltage at pin 3 is falling. As the voltage at pin 1 approaches its positive peak, diode D1 becomes forward

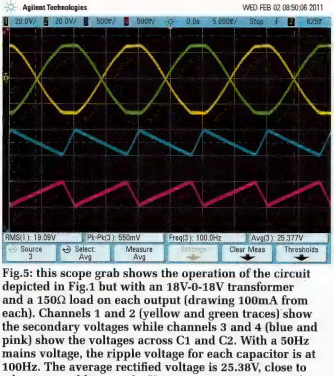


Fig.5: this scope grab shows the operation of the circuit depicted in Fig.1 but with an 18V-0-18V transformer and a 150Ω load on each output (drawing 100mA from each). Channels 1 and 2 (yellow and green traces) show the secondary voltages while channels 3 and 4 (blue and pink) show the voltages across C1 and C2. With a 50Hz mains voltage, the ripple voltage for each capacitor is at 100Hz. The average rectified voltage is 25.38V, close to what we would expect (19V x 1.414 - 2 x 0.7 = 25.47V).

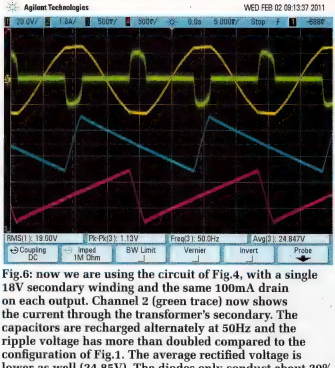


Fig.6: now we are using the circuit of Fig.4, with a single 18V secondary winding and the same 100mA drain on each output. Channel 2 (green trace) now shows the current through the transformer's secondary. The capacitors are recharged alternately at 50Hz and the ripple voltage has more than doubled compared to the configuration of Fig.1. The average rectified voltage is lower as well (24.85V). The diodes only conduct about 20% of the time, resulting in a low power factor.

biased and so capacitor C1 is charged to this peak voltage (or close to it). Similarly, as the voltage at pin 3 of CON1 approaches its negative peak, diode D3 becomes forward biased, charging capacitor C2 to the peak negative voltage.

Ten milliseconds later, the voltages are reversed. Diodes D2 and D4 are now forward biased and both capacitors are recharged but from the opposite winding. This process repeats 100 times a second since the mains frequency is 50Hz (in some countries, 60Hz).

The resulting filtered supply rails then supply positive and negative regulators REG1 and REG2. These vary their transconductance so as to maintain a steady voltage at their output pins, as determined by an internal voltage reference and divider network. In this case, we are using 7815 and 7915 regulators to derive +15V and -15V outputs respectively.

Want ±12V output rails instead? No problem, just substitute 12V regulators (eg, 7812 & 7912) instead, although for a given current drain, their dissipation will be somewhat higher. If this is a problem, substitute a transformer with a 24V centre-tapped (CT) secondary for the 30V CT unit shown.

Similarly, by changing the transformer and the regulators, you can get ±5V or ±9V outputs instead.

The 100µF capacitors on their outputs are not strictly necessary but they result in lower noise voltages at the outputs. They also improve the regulators' load transient response – if a sudden change in load impedance results in a change in the output voltages, current flows into or out of these capacitors as necessary to compensate, thus reducing the voltage variation.

The 100nF capacitors in parallel do the same but they have lower impedance at higher frequencies (due mainly to their lower dissipation or power factor) and so help with more rapid load transients.

LED1 and LED2, in combination with their current-limiting resistors R1 & R2, serve three purposes: (1) they provide a visual indication that the circuit is operating; (2) they provide the regulators with a minimum load; and (3) they help to discharge all the capacitors when the AC supply is removed.

Finally, diodes D5 & D6 protect the circuit in case of asymmetric loads. Such loads can pull the positive rail negative or the negative rail positive during switch-off or over-current conditions. D5 & D6 clip these transient voltages and prevent damage to the regulators and filter capacitors under such conditions.

D5 & D6 also overcome the bootstrapping problems that can occur with certain brands of regulators (mainly L78xx types).

Single rail configurations

The circuit of Fig.2 is similar in many ways to Fig.1 but lacks the negative regulator and its corresponding negative output rail. It also uses a transformer without a centre-tap but retains the bridge rectifier.

Note that in this case, we are using a 7812 3-terminal regulator to derive a +12V output rail. Accordingly, a transformer with a 12V secondary has been specified. If you wanted a +15V output, then its just a matter of using a 15V transformer and substituting a 7815 regulator.

Fig.3 also has a +12V output but uses a 24V centre-tapped transformer (12V-0V-12V) and a full-wave rectifier (D1 & D4). As before, it's easy to get a +15V output – substitute a 30V centre-tapped transformer and a 7815 regulator.

Half-wave rectifier

As with Fig.1, Fig.4 provides dual (±15V) outputs. In this case though, an untapped transformer is used and diodes D3 and D4 are removed, since there is no transformer secondary winding to drive them. As a result, diodes D1 & D2 function as half-wave rectifiers for their respective positive and negative rails.

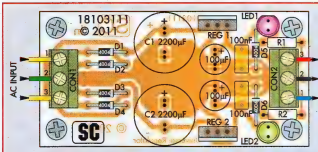


Fig.5: this PC board overlay diagram corresponds with the circuit of Fig.1. All components are installed. Refer to Table 2 for the values of resistors R1 & R2. Capacitors C1 & C2 are typically 25V types but a higher rating is sometimes necessary (see text).

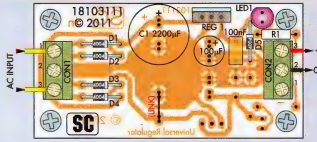


Fig.6: this PC board overlay diagram corresponds with the circuit of Fig.2. This is the only version for which a wire link is necessary. Note that quite a few parts are omitted for this version as there is no negative output voltage rail.

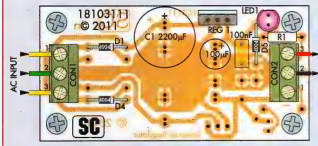


Fig.7: this PC board overlay diagram corresponds with the circuit of Fig.3. All the negative regulator components may be omitted, along with diodes D2 & D3.

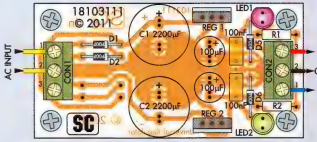


Fig.8: this PC board overlay diagram corresponds with the circuit of Fig.4. All components are installed except for diodes D3 & D4 although it won't hurt to put them in.

The other way of regarding Fig.4 is as a conventional half-wave voltage doubler circuit which has been "centre-tapped" at the junction of the two 2200µF capacitors. Either way, the result is the same.

Because D1 & D2 function as half-wave rectifiers, the ripple voltage superimposed on the DC supply rails will be 50Hz. As a result, for a given current drain, the ripple voltage will be slightly more than twice the 100Hz ripple obtained if the bridge rectifier circuit of Fig.1 is used. This may (or may not) be a problem, depending on the application (see Fig.6).

Selecting a transformer

Either a chassis-mount mains transformer or a plugpack can be used, as long as it has the correct voltage and current ratings. AC plugpacks are typically available with 9V, 12V, 15V, 16V or 24V output and power ratings up to about 24VA. These are suitable for regulated output currents of about 350mA for a split rail output or 700mA for a single voltage output.

If you want to use a chassis-mount mains transformer, you must take proper precautions to make your project safe and to avoid getting an electric shock. These include but are not limited to: earthing the transformer frame, the metal case and any exposed metal (eg, screw heads), proper colour coding for the wiring, an appropriate fuse, insulating mains connections within the case and so on.

If you are uncertain as to what precautions to take or don't have the necessary experience, don't mess with mains power!

It's quite easy to calculate the appropriate transformer voltage to use for a given output voltage or voltages. However, to save time, we have provided some tables to help you select a transformer.

It's just a matter of using Table 2 to select a transformer for Fig.1 (tapped secondary) or Fig.4 (untapped secondary). Similarly, use Table 3 to select a transformer for Fig.2 (untapped secondary) or Fig.3 (tapped secondary).

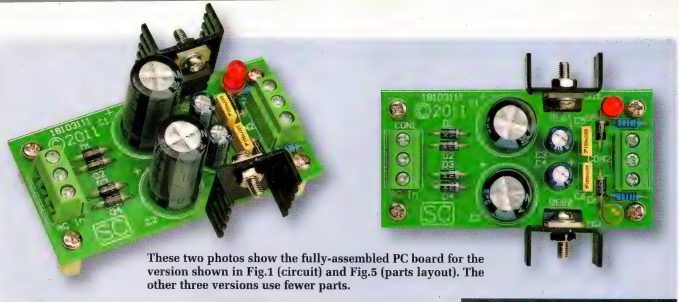
Note that you may use a transformer with a higher voltage rating than suggested but this will increase regulator dissipation and may require larger heatsinks (which will be discussed later).

In some cases, where the output current is moderate (say <250mA), it is possible to use a transformer with a slightly lower voltage rating than is indicated in these tables. For example, a 12V AC plugpack can be used to obtain ±15V regulated outputs at low current. This is because a transformer typically provides more than its rated voltage when it is lightly loaded.

Plugpacks tend to have worse voltage regulation than stand-alone transformers so this comment particularly applies to them. In other words, their output voltage will be even higher when they are lightly loaded.

Note that for transformers with secondary voltages above 16VAC (or above 30V AC with a centre tap), you must increase the voltage rating of the large input filter capacitors to at least 35V. If you can't get 35V capacitors, use 50V types instead. There is enough space on the PC board to fit most brands of 2200µF 50V capacitors but if necessary, use a smaller value (say 1500µF).

A multi-tapped transformer like the Jaycar MM2005 is a good choice for powering the Universal Regulator board because it can be configured with a single secondary winding of 9V, 12V, 15V, 18V, 21V, 24V or 30V or alternatively with a centre-tapped secondary winding of 18V (9-0-9),



These two photos show the fully-assembled PC board for the version shown in Fig.1 (circuit) and Fig.5 (parts layout). The other three versions use fewer parts.

24V (12-0-12) or 30V (15-0-15). Its secondary current rating (2A) is sufficient for virtually any configuration shown here.

Regulating DC

As stated previously, this board can also be used to regulate DC voltages. In this case, use the circuit of Fig.1 or Fig.3 depending on whether a negative voltage input is required. The transformer is, of course, deleted.

In either case, connect the supply ground to pin 2 of CON1. The supply rail(s) to be regulated then go to pin 1 (positive) and, in the case of Fig.1, to pin 3 (negative).

When used in this manner, the maximum regulated output voltage is the minimum input voltage minus 3V. So to obtain a regulated 12V output, the input must be at least 15V. Of course, you would have to use 7812 and 7912 regulators in Fig.1.

If the supply is an unregulated DC plugpack, its output will probably be several volts higher than nominal with light loads. So for applications which don't require a lot of current, you may find that a 12V DC plugpack supplies a high enough voltage for a regulated 12V output but you will have to check.

Heatsinks

For low-current applications (eg, driving a handful of op amps), heatsinks will not be necessary. Having said that, it's always a good idea to do the calculations for your application to be sure. If the regulators overheat they will shut down and the output voltage will drop dramatically. As a result, damage is unlikely but the circuit will not work correctly.

First, calculate the dissipation in each regulator. To do this you need to know the average input voltage to the regulators, which we shall call "Vin". A reasonable estimate can be calculated as: (secondary winding voltage) x 1.414 - 0.7V. You also need to know the peak current drawn from each output which we will designate as "Iout".

If we designate the regulator's output voltage as "Vout", then the dissipation in the regulator is simply (Vin - Vout) x Iout. For example, if a 15-0-15 (30V centre-tapped) transformer is used to provide a regulated ±15V at 100mA, the dissipation in each regulator will be roughly (20.5 - 15) x 0.1 = 0.55W. This is below 0.6W so no heatsinking is necessary.

Conversely, if the dissipation is over 0.6W, refer to Table 4 as a guide for heatsink selection.

Construction

Building the PC board is easy. The

Parts List

1 PC board, code 18103111, 71 x 35.5
2 3-way terminal blocks, 5.08mm pitch
4 M3 x 15mm tapped Nylon spacers
4 M3 x 6mm machine screws
2 TO-220 heatsinks (optional)
2 M3 x 10mm machine screws, nuts and shake-proof washers for heatsinks (optional)
10mm length of 0.71mm tinned copper wire

Semiconductors

1 78xx positive linear regulator (REG1)
1 79xx negative linear regulator (REG2 – optional)
6 1N4004 diodes D1-D6)
1 5mm red (LED1)
1 5mm green LED (LED2)

Capacitors

2 2200µF 25V* electrolytics
2 100µF 25V electrolytics
2 100nF MKT (code 100n or 104)

Resistors (0.25W, 1%)

2 2.2kΩ 2 680Ω
2 1.5kΩ
R1 & R2 – see Tables 1 & 2

* Note: a higher voltage rating is necessary for transformers with secondaries over 16V

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	2	2.2kΩ	red red red brown	red red black brown brown
❑	2	1.5kΩ	brown green red brown	brown green black brown brown
❑	2	680Ω	blue grey brown brown	blue grey black black brown

Table 2 – Selecting A Transformer For Dual Rail Outputs				
Output Voltage	Tapped Secondary	Untapped Secondary	Regulator(s)	R1 & R2
±5V	12V AC (6-0-6)	6-9V AC	7805, 7905	680Ω
±6V	15V AC (7.5-0-7.5)	9V AC	7806, 7906	680Ω
±8V	15V AC (7.5-0-7.5)	9V AC	7808, 7908	680Ω
±9V	18V AC (9-0-9)	9V AC	7809, 7909	680Ω
±12V	24V AC (12-0-12)	12V AC	7812, 7912	1.5kΩ
±15V	30V AC (15-0-15)	15V AC	7815, 7915	1.5kΩ
±18V	30V AC (15-0-15)	15V AC	7818, 7918	1.5kΩ
±20V*	36V AC (18-0-18)	18V AC	7820, 7920	2.2kΩ
±24V*	40V AC (20-0-20)	21V AC	7824, 7924	2.2kΩ
* Increase voltage rating of 2200µF capacitors to 35V or higher				

Table 3 – Selecting A Transformer For A Single Output Voltage				
Output Voltage	Untapped Secondary	Tapped Secondary	Regulator	Resistor R1
5V	6-9V AC	12V AC (6-0-6)	7805	680Ω
6V	9V AC	15V AC (7.5-0-7.5)	7806	680Ω
8V	9V AC	15V AC (7.5-0-7.5)	7808	680Ω
9V	9V AC	18V AC (9-0-9)	7809	680Ω
12V	12V AC	24V AC (12-0-12)	7812	1.5kΩ
15V	15V AC	30V AC (15-0-15)	7815	1.5kΩ
18V	15V AC	30V AC (15-0-15)	7818	1.5kΩ
20V*	18V AC	36V AC (18-0-18)	7820	2.2kΩ
24V*	21V AC	40V AC (20-0-20)	7824	2.2kΩ

Table 4: Heatsink Selection Guide		
Dissipation	Maximum Thermal Resistance	Suggested heatsink
<0.6W	45°C/W	None
0.6-2W	20°C/W	Micro/mini flag (Jaycar HH5502, Altronics H0630)
2-4W	12°C/W	Large flag (Jaycar HH8504, Altronics H0637)
4-8W	6°C/W	U-shaped (Jaycar HH8511, Altronics H0620)
>8W	48 ÷ dissipation in Watts	Finned diecast aluminium heatsink

board is coded 18103111 and measures 71 x 35.5mm. Before starting the assembly, it should be checked for hairline cracks or under-etched areas in the copper and repaired if necessary.

Figs.5-8 show the various configurations, so choose the one that's relevant for your application. If you are using the configuration shown in Fig.2 (positive output only, no centre tap), start by installing a wire link in place of C2. Do not install this link for any other configurations though.

Now install the resistors. Use Table 2 or Table 3 to select the correct values for resistors R1 & R2. If in doubt, use 1.5kΩ for both. R2 may be omitted if the negative output is not used.

Follow with the 1N4004 diodes. These must all be correctly orientated, as shown on the parts layout diagrams. If some are not used for your chosen configuration you may omit them, although it doesn't hurt to install all six.

Next, fit the two 100nF MKT capacitors. They can go in either way around. Follow with the LEDs, ensuring that the flat sides are orientated as shown on the relevant overlay diagram. After that, mount the two 3-way screw terminal blocks with their entry holes facing outwards.

The electrolytic capacitors can now be soldered in place, starting with the two smaller ones. They must all be correctly orientated. The stripe on the body indicates the negative side and these all face towards the bottom of the board. Make sure that the voltage ratings of C1 and C2 are sufficient for your application (see above).

If the regulators require heatsinks, it is best to fit them before the regulators are mounted (if possible). For larger heatsinks which may interfere with the PC board, crank the regulator legs slightly with small pliers so that the tabs line up with the edge of the board.

The regulator packages can then be pushed down onto the board, with the tab facing the edge, and soldered into place.

Finally, complete the board assembly by fitting tapped spacers to the four corner mounting holes. These can be secured using M3 machine screws.

Smoke test

If you are using a chassis-mount transformer, check that it has been correctly installed and that there are no exposed mains terminals before applying power. To test the unit, connect the transformer secondary leads to CON1, switch on and check that LED1 & LED2 light.

Assuming the LEDs do light, use a DMM to check the voltage(s) at CON2 to ensure that they are correct. If not, switch off and check that the correct regulators have been used. If there is no output at all, check that the regulators and diodes are orientated correctly.

Once you have confirmed that the output voltages are correct you can wire up the outputs. SC

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SERVICEMAN'S LOG

PC faults & the Christchurch earthquake

The 7.1 magnitude earthquake that struck Christchurch, New Zealand last September caused widespread damage to buildings and infrastructure. It also took out a lot of PCs due to both impact damage and power surges.

Items Covered This Month

- PC faults after the Christchurch earthquake
- Aircraft flap actuator
- Mobility scooter repairs
- Intermittent car radio

In the electronics/computer repair game, it's interesting to note the damage patterns resulting from certain natural events. For example, whenever we have a good lightning storm, there is always a flurry of power-supply related jobs coming through the workshop.

The major earthquake we had here in Christchurch last year was no exception. It happened at 4.35am and we lost power straight away. I immediately clambered over the wreckage of my house contents in pitch blackness to find my LED torch, which I knew lived on my workstation.

The torchlight revealed the destruction. In my corner of our home office, my Acer 24-inch flat panel had fallen face-first onto my ageing ergonomic keyboard and had smashed it. Miraculously, the monitor itself was undamaged (and unmarked), although I had to wait until power was subsequently restored to confirm this.

My PC's tower case which sits on the desk hadn't moved at all and nor had stacks of items on the upper shelf. On the other hand, out in my garage workshop, a 90kg drill press had been thrown two metres from its bench onto my radio-controlled model aircraft, destroying everything in its way.

It was a Saturday morning and as the day wore on, the work phones remained silent. Most people had far more serious issues than broken electronic gear or computers that no longer worked, such as houses broken in half or brickwork chimneys lying on their lounge room floor.

In the meantime, I had visions of my client's computers chucked every which way at my workshop across town. It was likely that I was going to have to break some very bad news to a lot of people and I felt sick just thinking about it.

I spent the day cleaning up the mess at home and making some metal brackets to secure our bookshelves. After all, there was no point simply standing them up again if an aftershock, which we were experiencing every few minutes, was going to send them toppling back over.

When power was finally restored at 6.30 that evening, I hit the power buttons on all the electronic equipment in my house. Miraculously everything still worked except for my computer. The monitor was fine but the machine itself was dead.

The next day, one of my staff made it through the cordons to the workshop and reported back that the total damage was a screwdriver on the floor. And so, with that off my mind, I decided to take a look at my PC to determine why it wouldn't power up. The first place to look was the power supply but with

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Dave Thompson: Our New Serviceman

Following the retirement of our long-standing serviceman, the column will now be taken over by Dave Thompson, who lives in Christchurch, New Zealand.

Dave's first venture into electronics occurred in 1969 when he pulled apart the brand new 7-transistor radio given to him for his seventh birthday. From there, he moved onto radio-controlled model aeroplanes during his teens, including giant-winged slope soarers, free-flight gliders and even a pulse jet speed model.

All this set him up for an apprenticeship and an 11-year career as an Avionics Engineer with Air New Zealand, before moving onto to various other jobs. He currently runs a repair company called PC Anytime in Christchurch, NZ, specialising in computer repairs and service (including monitors and printers).

Servicing Stories Wanted

We also welcome reader contributions for Serviceman. It doesn't matter what the story is about as long as it's in some way related to the electronics or electrical industries, to computers or even to car electronics or electrics. We pay for all contributions published but please note that your material must be original. Send your contribution by email to: **editor@siliconchip.com.au** and be sure to include your full name and address details.

the nearest replacement at my workshop, I decided it would have to wait.

On Monday morning, the phones started ringing in earnest. I was expecting that most of the problems would be due to impact damage, caused either by computers falling off desks or having something fall on them. However, while we did get a few of those, the vast majority were machines not powering up, just like mine.

It transpired that eyewitnesses had reported several reasonably large electrical-type explosions at local power stations, which gave off an intense blue/white light. What's more, those awake at the time the quake hit reported several severe power surges just before the power finally gave out, no doubt as emergency breakers kicked in (or out as the case may be). These surges apparently took out the power supply in my PC (and all those others), although it's interesting to note that my wife's machine was spared.

Ironically, my machine had an expensive modular supply, while hers is a standard, garden-type unit. Being less than a year old, it was fed back through the manufacturer's warranty system and was replaced with a shiny new one. It was something they really didn't have to do but was just one of the many acts of kindness I experienced in the aftermath of the quake.

Repairs to the majority of the machines we saw would ultimately be covered by the earthquake commission, as long as owners had some form of household insurance. For those that didn't, we tried replacing power supplies and other dead hardware under manufacturer's warranties and in most cases these were honoured, again a very kind gesture when they could have just as easily said "no".

Machines that had suffered impact damage were assessed and reports raised accordingly, though owners without any form of insurance had to spring for the whole cost of repair or replacement. This was often quite expensive, especially in the case of laptops which required chassis and/or screen replacements. We reduced our normal charges when we could, passing on some of the goodwill we experienced, but many had to forgo repairs because they simply couldn't afford the cost.

Aircraft flap actuator

In 1981, I was a second-year avionics engineering apprentice working for our national carrier. As far as technicians go, the guys there were regarded as among the best around and what they didn't know about avionics wasn't worth knowing. I couldn't believe my luck; my electronics hobby was becoming my profession. However, all that was still more than three years away and in 1981, the gaps in my knowledge were still vast.

As part of our apprenticeship, we were rotated every few months to different specialist workshops such as Instruments, Electrical, Radio/Radar and Simulators for experience. This story comes from my time in the electrical workshop, where I was involved in component overhaul.

After a few months of starter relays and similar simple repairs, I was entrusted with a "real" job, a flap actuator, which is a 24V motor with a planetary gearbox attached. As its name implies, this device is used to raise and lower the aircraft's flaps. The unit in question had come in with the complaint that it was low on power, stalling and popping the circuit breakers whenever it was operated.

This was odd because these actuators can usually move mountains; describing them as powerful is like calling Claudia Schiffer "presentable". Anyway, as with any job coming through the workshops, we initially did some tests to confirm the fault, although we already knew this actuator was faulty because it had been replaced and the replacement unit operated normally.

At switch-on, a serviceable unit draws up to 1500A peak current before falling back to a more reasonable level, depending on load. What's more, it's capable of delivering so much torque that we had half a large room specially adapted to house the torque test rig. Sure enough, this actuator didn't sound right – it was running slower and drawing more current than it should and when under load, it quickly sagged and popped the test-rig breakers. Fault confirmed.

Given the job of fixing it, I disassembled it as per the standard procedure. A large circlip holds the bearing and seal assembly at the output of the gearbox and this has usually bedded well into its slot. As a result, it needs considerable coaxing to remove it, all the while trying to avoid it "pinging" off and hitting some poor guy working nearby.

With the unit reduced to spare parts, the next step was to give it a thorough cleaning. This involved using various highly inflammable and nasty chemicals to strip away the grease and baked-on dirt accumulated over months of normal service.

Once everything had dried out, the armature was tested and it passed

without fault. The stator didn't fare so well. A resistance test measured far outside the acceptable range and an insulation test also failed, indicating a breakdown somewhere inside the windings. As a result, it was sent off to another department for rewinding if deemed salvageable or disposal if judged beyond repair.

I ordered a fresh coil assembly from stores and within a few hours the unit was back together and ready to test. This time it pulled as expected, with all measurements within acceptable limits. The completed job was then duly signed off by myself, my foreman and one of the workshop's two quality assurance (QA) engineers. After that, it was packed up and returned to stores, ready for re-deployment.

Unfortunately, that wasn't to be the end of the story. Several weeks later, I sensed something was going on in the boss's office; there was a flap on about something (no pun intended) and all the chiefs and QA guys were huddled in earnest conversation, looking over my way every now and then. From their manner, I knew I was involved and sure enough, I was soon summoned and told I would shortly be interviewed by air safety inspectors about the flap actuator I had repaired.

Apparently, it had failed in flight the previous day. My heart sank and I had visions of being consigned to permanent bird-strike engine clean-up detail before my career had even started.

My foreman told me not to worry and to just tell it how it happened. Besides, he reasoned, if anyone was going to be blamed, it wouldn't be me; whoever signed off the work would ultimately be responsible because I was a lowly apprentice and they should have checked everything I did. That may have been so but I certainly didn't want anyone getting into trouble over something I might have missed.

It turned out that the actuator had failed because that bearing/seal retaining circlip had come adrift. It had found its way into the gearbox, jamming it, damaging other parts and stalling the actuator before the breakers finally opened to prevent further damage. However, not only was the actuator now damaged beyond repair (at a cost of many thousands of dollars), so was the gearbox (at many more thousands of dollars).

However, that paled into insignificance when one thinks of the possible consequences. Fortunately, a manual flap winding handle in the cabin meant that the crew could still position the flaps and land safely.

Aircraft safety incidents like this are always thoroughly investigated, the cause determined and the blame (if any) apportioned accordingly. This investigation concluded the circlip had been assembled correctly but was likely faulty and had failed under duress, effectively exonerating all of us.

In most service work, if you mess up, at worst you might get an irate client or damaged hardware. In aircraft work, the stakes are much higher. I learned a very valuable lesson; double or triple-check everything potentially hazardous – it might just save someone's life.

Mobility scooter repairs

My Dad taught me an enormous amount about servicing over the years, even though he wasn't a professional serviceman as such. What he did do was custom-make

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CHRISTCHURCH TRANSMOGRIFICATION

all sorts of electronic and mechanical gadgets from scratch, as well as repair anything brought into his workshop by friends and business owners.

There was hardly anything he wouldn't take on (including jobs rejected by other servicemen) and this gave him (and eventually me) experience with a vast array of devices and technologies. Dad has now retired and because failing sight and dexterity means he can no longer tinker as well as he used to, I often step in to help him fix whatever he can't, er, fix.

Dad has to use a mobility scooter to go longer distances these days, though he can still wobble around his workshop without one. His first scooter needed some minor work and although relatively sophisticated, it still used an analog control circuit and he was able to configure it how he wanted it.

Some time ago, he acquired another scooter but it came with suspected electrical issues. And just like the old days, he would disappear into his workshop for hours on end in order to get it going again. Eventually, after repairing whatever needed repairing and tarting it up, he flicked that scooter on, making a tidy sum in the process.

The profits were invested in (you've guessed it) more dead scooters and he was soon repeating the process. However, his latest acquisition quickly went wrong. This one was a real bargain and we soon discovered why. It had "died" and "Brother-in-Law Incorporated" had already tried fixing it, leaving it in a right mess.

On the assembly side, many of the screws were stripped, while others had their fibre-glass anchors or posts cracked or snapped off. The batteries were ruined and the numerous plugs, most of which are unnumbered 2, 3 or 5-pin types, had been plugged into the wrong locations. As a result, it was highly likely that some of the components, or even the motor speed controller, had been damaged. In fact, the main fuse had blown, which didn't bode well.

Despite trawling the internet, I was unable to source any circuit diagrams for the scooter. Luck was with us though – one of Dad's other yet-to-be-sold units was the same brand and despite a few minor cosmetic differences, the handle-bar mounted controller "plugged and played" with this one. So simply comparing the two wire by wire should soon have the problem sorted – or so we thought.

It was a good theory and it might even have worked if the circuit boards and all the looms were identical but they weren't. Fortunately, however, the main 20-pin plug that connects the lights, motor, motor-speed controller and batteries in the "bottom half" of the scooter to the electronics/controller in the "top half" was the same in both units. This meant that the various switches and pots on the two controllers did the same things.

Eventually, using common sense and some educated guessing, we managed to rewire the non-working controller so that it closely mirrored the working one. We then replaced the main fuse, held our breaths and turned the key. The controller LEDs lit up as expected and the various switches all seemed to work their related peripherals.

Unfortunately, we also heard a series of loud beeps and these were in recurring patterns of long and short bursts. The handbook that came with the working scooter indicated that these beeps meant that "a problem was occurring". Now I'm not one to boast, but we had figured that much out already.

Beeping aside, we also had no motion. Everything else worked, so we had obviously wired those systems up correctly, but something in the motor management system wasn't quite right. We knew that the bottom end was fine, so the fault just had to lie in the controller itself but where?

Tracking down the faulty part without a circuit diagram would be too much of a hit or miss affair, while simply adopting a blanket approach and replacing every part on the PC board would be very time consuming. In short, I needed a circuit diagram and the only way to get one was to laboriously trace the circuit out.

I made hand-drawn diagrams of all the connections and then spent my spare time over the next few days tracing out the PC boards. Eventually, I was able to create a circuit diagram on my computer using schematic software (I use a program called Diptrace).

That done, it soon became evident one of the quad comparators in the circuit, an LM339N, wasn't working correctly. Also one of the transistors, handily unmarked, appeared open circuit. With some difficulty, I desoldered and replaced them with new components. The LM339 was easy enough and from the circuit I pegged the transistor to be a PNP type, so I substituted a 2N5401.

continued on page 96

Pre - Catalogue SALE March 2011

TV & Projector Brackets

Plasma TV Bracket 90 Degree Swivel

Suitable for LCD and plasma TVs from 32 to 60" and weighing up to 80kg. It's flexible, with a range of rotation of 90° from the twin 500mm extension arms, and allows a tilt of ±15°. The mounting plate allows for mounting on either 450 or 600mm stud centres and it allows for +2° lateral roll to ensure the TV is perfectly level after installation.

- VESA standard compliant
- Solid steel construction
- Mounting hardware & instructions included

CW-2828 WAS $199.00

$149.00
SAVE $50.00

Heavy Duty Ceiling Projector Mount

This is the heavy duty ceiling mounting bracket for unusual or odd sized projectors. This bracket does not affix to the top of the projector like many models but provides a secure platform for ANY projector with a width of 34 to 47cm and a weight of not more than 15kgs.

CW-2818 WAS $119.00

$89.00
SAVE $30.00

12" Foldback Speaker

Rated at 300WRMS this wide range speaker is ideally suited for use as a foldback speaker on stage or as reinforcement in an existing system. The box features a 4 ohm, 12" sub-woofer for rumbling bass and a horn tweeter to give crisp, clear mid range and high frequencies.

Enclosure Size: 650(W) x 330(H) x 440(D)mm
CS-2516 WAS $169.00

FREE speaker cover to suit with every purchase valued at $24.95

$129.00
SAVE $40.00

7" USB Plug and Play LCD Monitor

If you're in dire need of more screen real estate and don't want the hassle of a big bulky secondary monitor that needs its own power supply and display cable, this USB monitor is perfect. It's great if you're busy playing a game and still want access to your IM program like MSN or Skype. It has a nifty little rotatable screen and the display can be adjusted accordingly for portrait or landscape view.

- Compatible with Windows 2000/XP/Vista/7
- Dimensions:188(L) x 114(W) 35(H)mm

QM-3748 WAS $269.00

$219.00
SAVE $50.00

Pre - Catalogue

March 2011

Budget Four Channel Digital Video Recorder

This system allows you to monitor and record 4 locations at your home or office. This great value digital video recorder (DVR) package can store over 150 hours of video on the installed 250GB hard drive. Recording set-up is simple and various trigger modes can be set across the day including timer, motion detection, and manual recording.

The system comes complete with:

- 4-channel DVR with 250GB HDD, USB port, and 1 x composite video output
- 4 x weather resistant colour day/night cameras
- Plug-in interconnection cables
- Remote control
- Mains adaptor and user manual

QV-3063 WAS $599.00

$399.00
SAVE $200.00

7" LCD Monitor Surveillance Kit with 2 x CMOS Cameras

Simple, cost-effective surveillance solution for small scale indoor applications such as shops and small offices. Powered from one plugpack and all power and video is run along a single integrated cable. The LCD monitor also has an audio input to add a microphone if required.

Kit contains: 7" LCD monitor or monitor/DVR, 2 x CMOS colour cameras, 2 x 18m cables, mains adaptor, remote control & mounting brackets.

- Dimensions: 186(W) x 86(H) x 30(D)mm

QC-3640

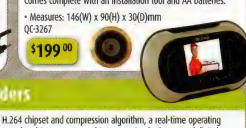
$199.00

2.5" LCD Electronic Door Peep Hole Viewer

Eliminate the small and distorted fish eye view that a traditional door peep hole provides with our electronic door peep hole viewer. With its big 2.5" LCD screen and a built in distortion compensation feature, you are able to see the person clearly on the other side of the door by a simple press of a button. The camera is no bigger than an original fish eye viewer and looks the same as a peep hole viewer from the outside. It is very simple to install without compromising door security. Comes complete with an installation tool and AA batteries.

- Measures: 146(W) x 90(H) x 30(D)mm

QC-3267



$199.00

In-Car Entertainment For Kids

Headrest with built in 7" Monitor and DVD player

DEAL BUY BOTH FOR $418 & SAVE $50

Will not only play DVDs, but also your video files such as DivX, MPEG4, etc and play videos on your USB stick or SD card. Connect an Xbox360® or Playstation3® via the AV input. Includes in-built games system (games CDs included), two game controllers and IR remote control.

- Supports infrared earphones
- Supports USB/MS/MMC/SD card
- Screen dimensions: 7inches
- Resolution: 1440 x 234 (16:9/4:3 selectable)
- Power: 12VDC
- Headrest dimensions: 280(W) x 200(H) x 110(D)mm

QM-3776

$269.00

7" TFT Colour Monitor with Headrest

If you already have a DVD player or other video source in the car, such as the QM-3776 (above) you can set this up as a second or third monitor. This model features a 7" TFT screen, with two composite video inputs and IR remote control and is identical in appearance to the QM-3776 - making them an excellent "pair" for a complete in-car video entertainment system.

- Screen dimensions: 7 inches
- Resolution: 1440 x 234 (16:9/4:3 selectable)
- System: NTSC/PAL
- Power: 12VDC
- 2 composite video inputs
- Headrest dimensions: 280(W) x 200(H) x 110(D)mm
- Dark grey leather-look upholstery

QM-3766

$199.00

Professional H.264 DVR Recorders

State of the art in digital video surveillance. Using the Techwell H.264 chipset and compression algorithm, a real-time operating system, video and audio encoding/decoding, hard disk recording and multi-stream networking. Featuring both DVR and digital video server capabilities, archive to DVD/CD or external USB mass storage device. Use either stand-alone or to build a powerful surveillance network. Suitable for banks, telecommunications, transportation, factories, warehouses, etc.

Available in two models:

8-Ch Professional H.264 DVR with 500GB HDD
Cat. QV-3044 WAS $1499.00 NOW $1299.00 SAVE $200.00

16-Ch Professional H.264 DVR with 1TB HDD
Cat. QV-3045 WAS $1999.00 NOW $1799.00 SAVE $200.00

FROM $1299.00
SAVE $200.00

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To order call
1800 022 888

Jaycar Electronics
Better, More Technical

Prices valid until 23/03/2011. Limited stock on sale items. No rainchecks. All Savings are based on Original RRP

Wireless 3 Outlet Mains Controller

Simply plug in any mains appliance rated up to 10A and use the remote to turn each one on or off individually, or control all of them together. One of the outlets also has an LED night light that's also operated with the remote. Real benefits for the elderly or disabled.

- Remote battery included
- 433MHz
- Remote measures: 125(W) x 45(H) x 17(D)mm.

MS-6142 WAS $44.95

$34.95
SAVE $10.00

Also available:
Spare Mains Outlet with Light MS-6143 $17.95
Mains Single Outlet/Light with Remote MS-6145 $24.95
A handy option if you only want to control one appliance

CREE® LED Downlight Kits

Featuring Cree® XR-E LEDs from 110 to 400 lumens, these offer comparable light to a 50W halogen downlight but at just 10% the power consumption! Life expectancy is over 50,000 hours. Power supply included.

1 x CREE LED Downlight Kit
- Over 110 lumens
- Power: 1.3W
- White beam 45°
- Size: 60 x 45mm (45mm cutout)

ZD-0370 WAS $49.95

$39.95
SAVE $10.00

4 x CREE LED Downlight Kit
- Over 400 lumens
- Power: 4.3W
- White beam 45°
- Size: 90 x 110mm (77mm cutout)

ZD-0372 WAS $129.00

$99.00
SAVE $30.00

Wind Generators

As well as the 200W model we now have a super-compact 300W version, and a big 500W unit for those who want to generate some serious power. All models feature external charge controllers with three-phase AC output, so you can install a long cable run without worrying about DC voltage drop.

NOTE: All wind generator models are supplied without mounting tower and associated mounting hardware.
WARNING: These wind generators are suitable for permanent terrestrial installations ONLY!

$349.00
SAVE $50.00

Check out our new 300W lightweight Wind Generators!

200W 12VDC
- Number of Blades: 3
- Included: generator, blades, tail, hub, nose cone, external charge controller

MG-4520 WAS $399.00

300W 12VDC MG-4580 WAS $599.00 NOW $549.00 SAVE $50.00
300W 24VDC MG-4582 WAS $599.00 NOW $549.00 SAVE $50.00
Features: moulded, compact, efficient blade design, are lightweight, have neodymium magnets, and the charge controllers are built into the generator heads.
- Number of Blades: 3
- Included: generator, blades, tail, hub, nose cone

Limited Stock

Spare parts available. See our catalogue or website for more details

500W 24VDC
- Number of Blades: 3
- Included: generator, blades, tail, hub, nose cone, charge controller

MG-4540 WAS $999.00

$849.00
SAVE $150.00

3,000,000 Candlepower Rechargeable Halogen Spotlight

The 3,000,000 candlepower provides 20min of continuous light for any outdoor activity. Rechargeable via mains or car cigarette lighter socket (both included). Ideal for rescue, shooting, fishing or boating.

- Built-in SLA battery
- Locking on/off switch
- High impact rubber lens protector
- LED map light
- Size: 210(L) x 150(Dia)mm

ST-3301

$29.95

Replacement globe SL-3221 $5.95

Low Frequency Inverter Sinewave 1200W

Suited to commercial applications, this sine wave low frequency inverter uses low frequency switching with large toroid output transformers to give ultra-robust performance and surge ratings much higher than conventional switchmode inverters. This results in lower standby power, lower heating and less wasted energy from the batteries. Being a pure sine wave, you can connect any device or appliance to the output even delicate electronics and equipment with variable speed motors. It also features a Green Power function - this is automatic load sensing which allows the inverter to remain in standby mode until an AC load is turned on. This conserves battery power as the inverter uses only about 10% of normal power when in standby mode. The amount of standby power required to start the inverter is user-adjustable.

- Dimensions: 465(L) x 280(W) x 120(H)mm

MI-5180
WAS $1099.00

$899.00
SAVE $200.00

MASSIVE SAVINGS

Renewable Energy - Design, Installation & Use

new

Renewable energy is expanding at an unprecedented rate. Solar panels are now commonplace and can be seen on suburban rooftops, factories and shops. Wind farms are a growth industry and small scale wind generators are commonly available, not to mention biofuels and micro hydro systems. This book explains renewable energy in an easy-to-read and understand format.

Softcover, 201 pages, 280 x 200mm
BE-1538

$38.95

Mini USB Power Adaptor - 1A

With 5VDC output at 1.0A, this little AC power adaptor can to charge pretty much any mobile phone or USB device, including all iPods® and iPhone® models. Also features worldwide voltage input making it great for travellers, just connect your USB charging cable (not included) and away you go.

- Input voltage: 100-240VAC, 50/60Hz
- Output: 5VDC, 1.0A
- Dimensions: 40(dia) x 27(L)mm

MP-3455

$14.95
new

Alkaline / Ni-Cd / Ni-MH Battery Charger

new

Now you can recharge AA or AAA alkaline batteries 10-20 times depending on their quality, age and condition as well as recharge Ni-Cd or Ni-MH batteries. LEDs indicate charge status and the on-board electronics prevent overheating or overcharging.

- Charges up to 4 x AA or AAA alkaline, Ni-Cd or Ni-MH batteries
- Microprocessor controlled to prevent overcharging
- Individual charge circuits for each cell
- Safety timer cutout
- Mains powered
- Dimensions: 71(W) x 118(H) x 30(D)mm

MB-3568

$49.95

Wind / Solar LED Garden Lights

With two sources of alternative energy available, you'll be able to always keep these weatherproof garden lights shining. The power generator has a 200mW solar panel and a wind generator that both recharges the built-in rechargeable battery to power the lights at night.

- Weatherproof
- 12 metre cable
- Includes 3 x LED spotlights
- Dimensions: 430(L) x 70(W)mm
- Blade diameter: 300mm

MG-4560 WAS $99.95

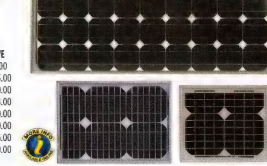
$89.95
SAVE $10.00

Powertech Monocrystalline Solar Panels

As strong and tough as the better known brands, but at a more attractive price.

- Sizes range from 5 watts to a massive 175 watts
- For full technical spec ask in-store or visit online
- QC tested - all come with test certificate
- 20 year limited warranty

Great new prices



	CAT	WAS	NOW	SAVE
12V 5 Watt	ZM-9091	$39.95	$34.95	$5.00
12V 10 Watt	ZM-9093	$89.95	$64.95	$25.00
12V 20 Watt	ZM-9094	$129.00	$119.00	$10.00
12V 40 Watt	ZM-9095	$249.00	$225.00	$24.00
12V 65 Watt	ZM-9096	$399.00	$359.00	$40.00
12V 80 Watt	ZM-9097	$449.00	$429.00	$20.00
12V 120 Watt	ZM-9098	$695.00	$639.00	$56.00
24V 175 Watt	ZM-9099	$949.00	$899.00	$50.00

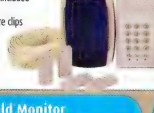
Home Alarm Systems

4 Zone Security Alarm with 2 Wire Technology

All system components (sensors, sirens) are connected to the control unit via a two core flat wire. The unit has a built- in keypad with status LED & three modes of operation (Home, Out, Off). All sensors and sounders are line protected so any attempt to interfere will sound the alarm.

Supplied with:
- Four-Zone system to set up multiple zones which can be monitored or enable independently (i.e. upstairs/downstairs or house & garage etc.)
- Main control unit
- Two PIRs
- Four door or window contact switches
- External switch
- External siren/strobe included
- 240VAC adaptor
- 50m two-core flat wire clips
- Screw/wall plugs
- Main unit: 160(H) x 185(W) x 35(D)mm

LA-5475



Accessories sold separately

Extra PIR with dual-element passive infra-red intrusion detector LA-5476 $29.95

A long range curtain lens with a vertical beam LA-5473 $6.95

Pet Alley Lens - Allows pets to move around in a protected area without setting off the alarm LA-5471 $6.95

$149.00

10 Zone Wired Alarm Kits

Fully configurable and programmable, these wired alarm kits give you complete control over a professional system for home or business. Each comes with a central controller and the sensors you need to get a basic system up and running, then you can add sensors and functionality as required. Up to four remote keypads can be installed at up to 100m range and each can be named for easy identification.

- 10 programmable zones • 4 access levels
- Walk test mode • Events memory in keypads
- Programmable timers for entry, exit and alarm duration

Both kits come with the following:
- 1 x control panel • 1 x Bellbox • 1 x 12V 1.2Ah backup battery

new

LA-5562 shown

Alarm with LED Controller
1 x Reed switch, 2 x PIR sensors, 1 x 50m cable
LA-5560 $299.00

Alarm with LCD Controller
2 x Reed switch, 4 x PIR sensors, 2 x 50m cable
LA-5562 $399.00

FROM $299.00

Spare controllers and sensors also available:
LED Remote Controller LA-5561 $49.95
LCD Remote Controller LA-5563 $69.95
PIR Sensor LA-5564 $29.95

2.5" CCTV Field Monitor

The smallest and lightest CCTV monitor on the market. Setting up and debugging CCTV and surveillance systems has never been easier. Rechargeable and ultra-portable. Complete with BNC cable, instruction manual and charger.

- Pixel: 480 x 234
- Power: 5VDC
- Video input: PAL
- Dimensions: 85(L) x 64(W) x 20(D)mm

QM-3821 WAS $149.00

$99.00
SAVE $50.00

2-Wire CCTV Video/Power Processor

Dramatically reduce the cost of your next CCTV installation. Run composite video and power from CCTV cameras over distances up to 500m on UTP - no coax or separate power supplies required. Suitable for cameras that operate on 12VDC @ 350mA max. With a built in DSP, it eliminates any interference picked up within the length of the cable providing you with crystal clear video images.

Two types available:

Single Channel CCTV Video/Power Processor
- Video output 1Vp-p 75-ohm
- Dimensions: 110(L) x 72(W) x 28(H)mm

QC-3263 WAS $89.95 NOW $59.95 SAVE $30.00

FROM $59.95
SAVE $30.00

4-Channel CCTV Video/Power Processor
- Dimensions: 145(L) x 80(W) x 28(H)mm

QC-3265 WAS $299.00
NOW $229.00 SAVE $70.00

Handheld Micro Inspection Camera

The Digitech handheld micro inspection camera allows you to perform a detailed visual inspection in hard to reach areas. Its pistol grip design and detachable 2.4GHz monitor make it easy to locate and diagnose the unreachable.
Requires 4 x AA Batteries.

Camera:
- Image sensor: CMOS
- Resolution: 704 x 576 pixels
- Dimensions: 186(W) x 41(H) x 145(D)mm (Excluding gooseneck)

Monitor:
- LCD Screen Type: 2.5" TFT-LCD
- Effective pixels: 480 x 240
- AV output for recording
- Dimensions: 100(W) x 70(D) x 30(H)mm

QC-8700 WAS $249.00

$199.00
SAVE $50.00

Biometric Fingerprint ID Access Control

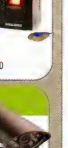
Control a single door or use multiple units on a site connected to a PC via an RS232, RS485 or Ethernet connection. Up to 500 users can be enrolled and each have access restricted to certain times. Software included.

- 12VDC 3A relay output
- Requires 9VDC @ 500mA
- Dimensions: 180(L) x 82(W) x 55(H)mm

LA-5121 WAS $499.00

$199.00
SAVE $300.00

Also available
Universal RFID /Fingerprint Access Controller
LA-5122 WAS $299.00 NOW $159.00 SAVE $140.00



Professional Cameras 550 TVL

ExView Colour CCD - Pro Style

A high resolution Sony ExView HAD CCD-equipped camera to dramatically improve low light performance. Ideal for use with infrared illuminators & features high speed electronic shutter, back light compensation & 3 stage automatic gain control.

- Sensor resolution (H x V pixels): 752 x 582
- Resolution: 540 TVL
- Power: 24VAC/12VDC
- Weight: 500g

QC-8622 WAS $299.00

$249.00
SAVE $50.00

Also available:
Pro 550TVL Dual Voltage CCD Camera
QC-8623 WAS $399.00 NOW $349.00 SAVE $50.00

Camera Lenses

These high quality C mount lenses have been carefully selected to match our range of professional cameras. Mounting adaptors included.

$19.95 ea
SAVE $5.00

4mm Lens 80° viewing angle
QC-3315 WAS $24.95
NOW $19.95 SAVE $5.00

6mm Lens 53° viewing angle
QC-3316 WAS $24.95
NOW $19.95 SAVE $5.00

8mm Lens 40° viewing angle
QC-3317 WAS $24.95
NOW $19.95 SAVE $5.00

Wireless Digital Mini DVR Systems

These mini DVR systems operate on the 2.4GHz digital band which means stable, interference free transmissions. No cabling means easy set up. Great for a wide range of applications.

Two models are available, both include one colour outdoor day/night camera with motion sensor, a ball & socket mounting bracket, and utilise channel hopping to prevent interference. Both have easy to navigate system settings, manual recording, schedule recording or record with motion detection. Both use SD cards (not included) to store video and playback is via the SD card to a PC.

FROM $299.00

2.4GHz Digital Wireless Receiver with Camera
QC-3630 $299.00

2.4GHz Digital Wireless Display/ Receiver with Camera and Integrated 7" LCD
QC-3632 $399.00

Additional or spare camera: QC-3634 $189.00

Limited stock on sale items.
All Savings are based on Original RRP

Jaycar Electronics
Better, More Technical

Travel Companion!

DEAL BUY BOTH FOR $158.95 & SAVE $40

7" TFT LCD Widescreen Colour Monitor

A truly versatile monitor with low power consumption, wide viewing angle and NTSC and PAL compatibility. Suitable for in-car entertainment, use it to watch DVDs, PS2®, XBOX®, etc. Unit comes with an adjustable swivel bracket with double sided tape for adhesion on clean flat surfaces. A very slim and small infrared remote control is included.

- Power input: 12VDC
- High resolution wide screen format
- Ideal for rear seat passengers

QM-3752

$159.00

Wireless Stereo Headphones

new

Having the kids watching DVDs in the back of the car is all very nice, but you don't want to be blasted with endless episodes of Spongebob Squarepants or The Wiggles for hour after hour. Add a pair of wireless headphones and enjoy automotive bliss. Soft cushioned earpads for comfort, switchable between channel A and B.

- Driver diameter: 27mm
- Nominal impedance: 32 ohms
- Frequency response: 120Hz - 20kHz
- Sensitivity: 100dB

AA-2047

$39.95

Also suits our Headrest DVD Monitor on Page 1

Response Precision Car Amplifiers

With improved heat sinks and upgraded low-profile chassis design, each model delivers surprising grunt and performance in a sleek and compact package that fits neatly under a car seat. All include gold plated power and speaker terminals and variable low pass filters. Our class AB amps come with variable high pass filters and pass through RCAs; while our class D subwoofer amps feature variable subsonic filter, phase shift and master/slave operation.

2 x 80WRMS Class AB Amplifier
Dimensions: 266(L) x 235(W) x 58(D)mm
AA-0450 WAS $149.00
NOW $129.00 SAVE $20.00

4 x 50WRMS Class AB Amplifier
Dimensions: 316(L) x 235(W) x 58(D)mm
AA-0451 WAS $199.00
NOW $169.00 SAVE $30.00

2 x 150WRMS Class AB Amplifier
Dimensions: 376(L) x 235(W) x 58(D)mm
AA-0452 WAS $229.00
NOW $199.00 SAVE $30.00

4 x 100WRMS Class AB Amplifier
Dimensions: 436(L) x 235(W) x 58(D)mm
AA-0453 WAS $299.00 NOW $249.00 SAVE $50.00

FROM $129.00 SAVE OVER 15%

500WRMS Linkable Class D Subwoofer Amplifier
Dimensions: 232(L) x 178(W) x 58(D)mm
AA-0454 WAS $249.00 NOW $219.00 SAVE $30.00

1000WRMS Linkable Class D Subwoofer Amplifier
Dimensions: 306(L) x 178(W) x 58(D)mm
AA-0455 WAS $369.00
NOW $329.00 SAVE $40.00

Solar Powered LED Garden Lights

Save energy with one of these solar spotlights! When darkness falls, the spotlight switches on automatically. They use high-powered LEDs and a built-in solar panel to charge the internal batteries during the day and allows the system to operate during the night.

Solar Powered LED Spotlight with Passive Infrared Motion Sensor

- 30 LEDs
- Illumination duration: 20, 40, or 90 sec. PIR controlled
- PIR Sensing range: 15 metres

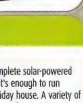
SL-2718 WAS $99.00

$69.00 SAVE $30.00

Solar Powered LED Spotlight

- 30 LEDs
- Illumination duration: 10 hours

SL-2716
WAS $149.00



$99.00 SAVE $50.00

Solar Powered LED Garden Spotlight

- 11 LEDs
- Illumination duration: 10 hours

SL-2714 WAS $59.95

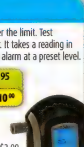
$49.95 SAVE $10.00

38Ch 0.5W Transceiver

This lightweight hand-held transceiver is suitable for all professional and recreational activities such as hiking, boating, kayaking, building sites, IT-cablers, electricians, inter-car road trip communication or farming, etc. Open field transmission range is up to 5km, with typical city range up to one kilometre.

- Covers Australian 38 UHF CB channels and repeaters
- Green backlit LCD screen
- 0.5W maximum RF output
- Range up to 5km
- No licence required
- Requires 4 x AAA
- Dimensions: 105(H) x 60(W) x 35(D)mm

DC-1023 WAS $49.95



$39.95 SAVE $10.00

LCD Alcohol Tester

Don't get behind the wheel if you're over the limit. Test yourself first with your own breathalyser. It takes a reading in less than five seconds and can sound an alarm at a preset level.

- Accuracy of .04mg/L
- Backlit LCD
- Requires 3 x AAA batteries

QM-7296 WAS $69.95

$59.95 SAVE $10.00

Also available:
Replacement mouth piece
QM-7297 WAS $9.95 $ NOW $6.95 SAVE $3.00

Please note: this product is intended to give an indicative reading only and is carries no guarantee of accuracy. Jaycar accepts no responsibility for any consequence arising from the use of this device.

Vifa Subwoofers

These premium range Vifa car subwoofers produce genuine high fidelity sound quality. With dual voice coils, high power handling and die-cast aluminium chassis, they don't just deliver brilliant low-register bass clarity but also thump tremendous SPLs like only Vifa speakers can. 10" or 12" models available.

10" Subwoofer
200WRMS @ 2 x 4 ohms
CS-2351 WAS $249.00

$229.00 SAVE $20.00

12" Subwoofer
250WRMS @ 2 x 4 ohms
CS-2353 WAS $299.00

$269.00 SAVE $30.00

Solar Lighting Kit

45W Solar Lighting Kit

Just add a battery and you have a complete solar-powered lighting setup. With 45 watts output, it's enough to run auxiliary lights on a farm shed or holiday house. A variety of output options including a 5V USB port and a 12V cigarette lighter socket. Panels, mounting hardware, lights, cable, junction box and charge controller included.

Power output: 15 watts per panel,
Nominal voltage output: 14.5VDC
Outputs: 3V, 6V, 9V, 12V, 5V USB.
Panel dimensions: 925(L) x 315(W) x 22(D)mm

Recommended battery: 15 - 45Ah
MP-4554 WAS $499.00

$399.00 SAVE $100.00

Also available
10W Solar Lighting Kit
MP-4552 WAS $219.00
NOW $149.00
SAVE $70.00
Limited Stock

Wireless Weather Stations

Perfect for the enthusiast forecaster or professional alike, they utilise a collection of wireless environmental sensors that transmit data to a base station to keep you updated on current and future weather conditions. Both will measure indoor/outdoor temperature, humidity, rain, wind speed, wind chill, and displays the date/time. Both feature:

- Display in Celsius or Fahrenheit
- Records all min/max values with time and date of their recordings
- Storm warning alarm
- Solar powered sensors

Wireless Weather Station - Basic
- Wireless transmission range 50m

XC-0346 WAS $149.00

$99.00 SAVE $50.00

XC-0346

Touchscreen Wireless Weather Station with Computer Interface
- Touch screen LCD panel, LED backlight
- Connect to your computer through USB, download, store and analyse weather data
- Weather forecast tendency arrow
- Wireless transmission range 50m

XC-0348 WAS $199.00

$149.00 SAVE $50.00

XC-0348

Better, More Technical

All Savings are based on Original RRP
Limited stock on sale items.

To order call 1800 022 888

Camping Gear – 12VDC

Camping Shower

Wash away the cares of the day with a warm bucket of water and this excellent camping shower. Simply plugs into your car's cigarette lighter and away you go. Pump, tubing, showerhead, hanging hook, carry bag and 4.8m power cable all included.

YS-2800

$24.95

Portable Stove

Cooks, warms or reheats at up to 125°C. Deep lid design, with a case made from durable ABS plastic and carrying handles.

- Measures: 265(L) x 180(W) x 155(H)mm

YS-2808

$49.95

Stainless Steel Travel Mug

This handy travel mug has a built-in, thermostatically controlled heater and will maintain one of four selectable preset temperature settings ranging from room temp to very hot.

- Holds 500ml
- Includes 1.5m detachable 12V power lead with cigarette lighter plug

GH-1301

$29.95

Retractable Cigarette Lighter Extension Cord

Handy for 4WD and camping use, this three metre extension cord retracts into its rugged housing to keep it protected and tangle free.

- 5 amp fuse
- Power indicator

PP-1990 Was $16.95

$12.95
SAVE $4.00

Modified Sinewave Inverters

These inverters will produce mains power from your vehicle's battery. A 150W inverter will run some laptops, lights, small TVs & recharge batteries. Inverters 300W & above will also recharge power tools, run flourescents & larger style TVs. Take your creature comforts with you when you go bush or on any road trip.

FROM $49.95

150W 12VDC to 230VAC
MI-5102 $49.95

NEW prices

300W 12VDC to 230VAC
MI-5104 WAS $79.95
NOW $69.95 SAVE $10.00

400W 12VDC to 230VAC
MI-5106 WAS $139.00
NOW $99.00 SAVE $40.00

400W 24VDC to 230VAC
MI-5107 WAS $139.00
NOW $99.00 SAVE $40.00

600W 12VDC to 230VAC
MI-5108 WAS $199.00
NOW $169.00 SAVE $30.00

800 Watt 12VDC to 230VAC
MI-5110 WAS $249.00
NOW $199.00 SAVE $50.00

1000 Watt 12VDC to 230VAC
MI-5112 WAS $329.00
NOW $299.00 SAVE $30.00

1500 Watt 12VDC to 230VAC
MI-5114 WAS $499.00
NOW $449.00 SAVE $50.00

2000 Watt 24VDC to 230VAC
MI-5116 WAS $599.00 **NOW $549.00** SAVE $50.00

Pure sinewave inverters also available. See in-store or on website.

Save Over 20%

BIG Savings on Inverters

10 Million Candle Power Spotlight with Fluoro Reading Light

Features a super powerful 12V 100Watt Halogen globe. A switch for dim lighting to conserve power when high brightness is not required, and twin fluorescent globes for reading or as a work light. The spotlight is powered by a rechargeable 12V 7Ah battery that can be charged either at home or in the car.

- Battery: 12V 7Ah SLA
- Lens Diameter: 180mm
- Supplied with mains, in-car charger and carry strap.

SF-3308 WAS $89.95

$69.95
SAVE $20.00

12V Auto Work Light

Ideal for use in caravans, boats, 4WDs and cars. This 12V auto work lamp draws a little over an amp and is supplied with 4.5m power cord and a cigarette lighter socket for easy connection.

- Length 320mm

SF-3032 WAS $17.95

$12.95
SAVE $5.00

E-Charger Power Bank 12V/USB Charger

This unit is designed for use on 12V vehicles and will assist if the starter motor turns the engine over too slowly to start. With a USB and a female automotive accessory socket , this unit also serves as a back-up device for other equipment such as mobile phones, PDAs and iPods®. See our website for full specifications.

- Mains Powered

MB-3597 WAS $69.95

$34.95
SAVE $35.00

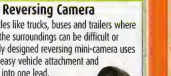
Colour CCD Reversing Cameras

Mini Colour CCD Reversing Camera

Suitable for larger vehicles like trucks, buses and trailers where getting a clear view of the surroundings can be difficult or impossible. This uniquely designed reversing mini-camera uses a mounting bracket for easy vehicle attachment and combines power/video into one lead.

- Waterproof (IP68) colour CCD camera
- Image sensor:1/4" colour CCD
- Power supply: 9-12VDC
- Camera size: 18mm (Dia)

QC-3727 WAS $249.00



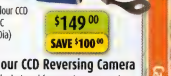
$149.00
SAVE $100.00

Flush Mount Colour CCD Reversing Camera

This camera is specifically designed for rear-view systems in cars and trucks.It comes with a detachable video and power lead so you can easily run the cable back to the monitor. An image reversal lead is fitted and the camera will operate in 'reverse mode' or ' normal mode', depending on how it's wired up.

- Resolution: 380 TV lines
- Sensor: 1/4" CCD colour sensor
- Viewing angle: 150 deg
- Supply voltage: 12VDC @ 75mA
- Measures 22(dia) x 40(L)mm

QC-3728 WAS $249.00



$149.00
SAVE $100.00

Ready for caravans

Network DVR with 10" Monitor & Camera Kit

new

This surveillance package offers exceptional value for money. It includes a H.264 DVR with built-in 10" LCD monitor and 320GB HDD, 2 indoor/outdoor CMOS 350TVL cameras with IR illumination for night viewing, 2 x 18 cables and power supplies. Everything you need in one box! Recording can be started manually, by programming or by triggered alarm conditions. The main feature is the Smart Phone support and the iPhone® app you can download from iTunes® to view live or recorded footage". Monitoring may be done real-time on a monitor, LAN network, via internet or Smart Phone. The DVR functions can be controlled by mouse or the IR remote control.

- DVR dimensions: 208(L) x 85(W) x 242(H)mm
- Camera dimensions: 115(L) x 45(H)mm

*App is free for single use and may incur a charge for multi-user

QV-3030 WAS $799.00

$699.00
SAVE $100.00*

Budget DVR Kits with Colour Cameras

Ideally suited to smaller surveillance installations around the home or office. These 4 channel systems can store over 150 hours of video on the 320GB HDD. Recorded video is indexed in an event log and can be viewed via a computer or external monitor. Complete with weather resistant IR cameras, cables, remote control and mains adaptors.

FROM $379.00
SAVE OVER 20%

DVR
- 4 x camera inputs
- 1 x composite video output
- MJPEG compression
- SATA hard drive interface
- 320GB Seagate SV35 Surveillance Hard Drive

Two models available:

4 Channel DVR Kit with 2 IR Cameras QV-3020
WAS $499.00 NOW $379.00 SAVE $120.00

4 Channel DVR Kit with 4 IR Cameras QV-3024
WAS $599.00 NOW $499.00 SAVE $100.00

Camera
- CMOS sensor, 350TV lines
- Inbuilt infrared illumination
- Day/night operation

QV-3024 shown

Limited stock on sale items.
All Savings are based on Original RRP

www.jaycar.com.au

Jaycar Electronics
Better, More Technical

Gas Soldering Iron Kit

Everything you need to solder, silver solder, braze, heatshrink or strip paint etc. Refillable with stand, extra tips, torch and cutting attachment.

$29.95
SAVE $10.00

- 3 soldering tips
- 1 torch attachment
- 1 rope cutter
- 178mm long

TS-1112 WAS $39.95

Micro Engraver

new

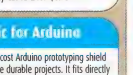
Engrave your valuables for security or insurance. The tiny diamond coated tip spins at 10,000 RPM so you can personalise tools, sporting gear, toys, security ID on valuables etc. Engraves glass, ceramics, metals and plastics. Batteries and case included. Tip is replaceable.

$19.95

- Size: 160(L) x 15(Dia)mm

TD-2468

Replacement tip sold separately Cat TD-2469 $6.95



Handy Service Aids!

Solder Flux Gel Paste 10g Syringe

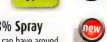
A mildly activated, resin-based flux formulation developed for a wide range of applications, leaving a pin-probeable residue. Very low post-process residue, which remains clear and probable even at the higher temperatures required for lead free solders.

- 10g syringe
- Superior wetting
- Suitable for lead-free solders
- Reduces or eliminates voiding

NS-3039

$19.95

new



Isopropyl Alcohol 99.8% Spray

The most useful service aids you can have around. Use as head cleaning, surface cleaning and prep, contact cleaning, stain removal in the laundry etc. It's also a medical-grade surface disinfectant. Easy to use pump pack spray bottle & dries quickly.

- 99.8% Isopropyl Alcohol
- 250ml Bottle

NA-1066

$8.95

new

Super Glue Debonder 20ml

Cyanoacrylate, better known as super glue is tenacious in sticking skin together, and has been exploited as an alternative to surgical sutures. Debonder will quickly and painlessly separate skin stuck with super glue.

$1.95
SAVE $2.00

20ml bottle with applicator
NA-1501 WAS $3.95

Chip Quik SMD Removal Kit

Chip Quick is a low melting point solder product that maintains the molten state of a row of pins. It even works on PLCC chips. Essential rework tool for anyone who uses SMD components. 1cc lead-free alloy kit will remove 8 - 10 SMD PLCC chips.

$29.95
SAVE $10.00

NS-3050
WAS $39.95

CHIPQUIK

Atmel 328 Development Module

A copy of the exact Arduino Duemilanove board. It contains the AT Mega 328 microprocessor with a boot loader program so that you can communicate with it at switch-on. It has the standard I/O and is 100% compatible with the original Arduino concept. It contains some documentation and assembly instructions.

XC-4210

$39.95

new

ProtoShield Basic for Arduino

The ProtoShield Basic is a low-cost Arduino prototyping shield that enables you to make more durable projects. It fits directly onto an Arduino or Freeduino compatible board and has a large area in the middle where you can solder on your own parts. The PCB surface is gold-plated for maximum durability.

- Yellow solder mask
- Mounting pads for: reset button, power on LED and current-limiting resistor & power supply capacitors
- Size: 59(L) x 53(W)mm

XC-4214

$4.45

new

60 Piece Rotary Tool Bit Set

All the bits you need for your rotary tool to grind, polish, cut, sand or clean. All housed in a durable case with transparent lid and carry handle. See website for full contents.

- Case size: 220(L) x 130(W) x 45(D)mm

TD-2457

new

$9.95

30 Piece Electronic Tool Kit

new

An electronic tool kit with all the essentials - cutters, pliers, Phillips head, slotted, Pozidriv, nut drivers etc. screwdrivers etc. Ideal kit for computer service people. See website for full contents.

- Case size: 210(L) x 140(W) x 38(D)mm

TD-2107

$29.95

Savings on Test Equipment!

Semiconductor Component Analyser

Intelligent semiconductor analyser that offers simple identification and testing of a variety of 2 or 3-pin devices. Type and lead identification as well as forward voltage, test current and other parameters for transistors.

- Automatic type identification of BJTs, Darlington, MOSFETs, JFETs, triacs, thyristors, LEDs, diodes and diode networks
- Gain and leakage current measurement for BJTs
- Silicon and germanium detection for BJTs
- Forward voltage and test current
- Dimensions: 100(W) x 71(H) x 27(D)mm

QT-2216 WAS $99.00

$79.00
SAVE $20.00

Digital Lightmeter

A handy lightmeter for photography, lab work, architectural, engineering and construction. 3 ranges to .01 to 50,000 lux. Battery and sensor cover included.

- Measures 0.01 to 50,000 Lux
- 1999 Count LCD
- Battery: 1 x AA23 (12V)
- Dimensions: 188(L) x 64(W) x 24.5(D)mm

QM-1587 WAS $49.95

$44.95
SAVE $5.00

Cat III Dynamo-Powered DMM

Just crank the handle for 10 seconds to provide power for approx 10 minutes operation. Ideal for electrical emergencies on the car or boat. The unit also has provision to be powered by 2 x CR2032 batteries for those days when kinetic energy is not available.

- No batteries required
- Data hold
- 10A current
- Display: 4000 count
- Dimensions: 152(L) x 78(W) x 45(D)mm

QM-1547 WAS $79.95

$44.95
SAVE $35.00

Coax Cable Tester

Simply connect it to the F-connector and it will give you an audible signal and a red/green go/no go signal to tell you if there's a short, an open in your cable or connectors. The F-connector is removable, so you can fit an adaptor for different types of connectors.

- Machined from aluminium
- Requires 1 x AAA battery
- 100mm long

QP-2289 WAS $36.95

$29.95
SAVE $7.00

12VDC Voltage Polarity Easy Tester

Performs five essential tests in the field: voltage, load, polarity, voltage drop and continuity. The load applied is selectable between 1A or 500mA to test wiring depending on location, device to be tested, and anticipated voltage drop. Ideal for CCTV and security installers, car audio, roadies, AV techs etc.

- Dimensions: 51(L) x 44(W) x 29(H)mm

QP-2215 WAS $24.95

$19.95
SAVE $5.00

Mini Non-Contact IR IP67 Thermometer

Ultra compact, non-contact thermometer. IP67 rated so is ideal for industrial and lab applications. LCD readout gives temperature in Celsius or Fahrenheit. Batteries and lanyard included.

- Measurement range: -33 - 110°C (-27 - 230°F)
- Accuracy: ±1°C
- Response time: 1 second
- Size: 82(L) x 17(Dia)

QM-7218 WAS $39.95

$29.95
SAVE $10.00

Better, More Technical

All Savings are based on Original RRP
Limited stock on sale items.

To order call 1800 022 888

3 Speed Belt Drive Turntable with Analogue and USB Audio Output

This handy turntable is perfect for playing old vinyl records. You can also make back-up copies in a convenient digital format via the USB connection. The turntable plays singles, EPs, albums and even your old 78s.

- Analogue or digital audio output
- 33/45/78 rpm
- 240 volt powered
- Magnetic cartridge
- NAB centre adaptor

GE-4059
WAS $79.00
$39.00
SAVE $40.00

Keyboard, Mouse, Monitor Lead for P/S2 Switchbox

Combined Keyboard, Mouse and Monitor lead to provide a neat connection between your computer and PS/2 Switchbox (XC5066). A considerable saving compared to buying three separate cables.

- 1 metre
- Colour coded connectors
- Ferrite suppression on monitor lead

WC-7570 WAS $19.95
$9.95
SAVE $10.00

Tiny 300k Notebook USB Webcam

Excellent for on-the-go online video conferencing or chatting. It has a built-in microphone to keep setup to a minimum. Comfortably mounts on top of a thin LCD laptop screen.

- Driverless, plug and play
- Dimensions: 28(W) x 59(H) x14(D)mm

QC-3231 WAS $29.95
$19.95
SAVE $10.00

8-Port Hub Switch

High performance 8 port, 10/100/1000 N-Way switch increases network performance and reduces congestion. The switch also supports auto-negotiation which allows each port to be operated at a different speed while maintaining maximum throughput. Plugpack included.

Max cable length:
100 metres
Transmission speed:
10/100/1000Mbps
Size: 180(W) x 103(D) x 27(H)mm
YN-8087 WAS $99.00
$79.00
SAVE $20.00

USB Optical Mouse with Number Keypad

A combination USB keypad and mouse. Simply plugs into the computer's USB port and gives you a full function numeric keypad and mouse. Lead length 700mm.

- Measures: 67(W) x 110(L) x 20(H)mm

XM-5138 WAS $37.95
$19.95
SAVE $18.00

PCMCIA Fingerprint ID for Laptops

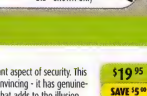
Slides into the PCMCIA slot of a laptop and utilises biometric technology to identify authorised users of the computer. Mainly intended for laptops but can be used on any computer with a PCMCIA slot. Software included.

- Dimensions: 90(L) x 54(W) x 4.8(H)mm

XC-4843 WAS $129.00
$59.00
SAVE $70.00

Silicone Hard Drive Protectors

Provides a layer of cushion against shock and impact for either a 3.5" or 2.5" hard disk drive (HDD). They are a two piece design with the smaller piece removable to enable the HDD to be plugged into one of our HDD docking stations, and the larger piece stays on which keeps most of the HDD still protected. Supplied in a pack of two, designed for a 3.5" and 2.5" HDD.



Dimensions
3.5" 158 x 118 x 33mm
2.5" 107 x 80 x 18mm
XC-4650
$8.95
3.5" shown only

USB Powered!

USB Powered Extension Lead with 4-Port Hub

Extend your printer or any other USB device as far as 10 metres away from your PC. A 4-port hub adds extra flexibility. Powered by USB from the host computer.

XC-4122 WAS $49.95
$39.95
SAVE $10.00

3-Port Motorised Retracting USB Hub

Just touch the top and your USB hub will rise from the surface of your desk to do your bidding. Touch it again and it lowers itself back into place and out of the way. It has 3 USB 2.0 ports and also acts as a cable grommet to keep all your computer cables neat and tidy.

- Powered by USB
- Mounting hole: 75mm
- Mounting depth: 70mm
- Diameter: 92mm

XC-4877 WAS $29.95
$9.95
SAVE $20.00

USB to 1080p HDMI

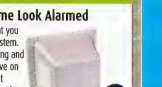
Listen to your iPod® or MP3 player without missing a call from your mobile phone. It connects to the headphone jack of your iPod® or music source and will cut out the music to allow the call. Supplied with a 1.5m USB lead, 730mm sound source interface lead and bud-style earphones.

- Lightweight
- backlight button
- Charges via USB

XC-4894 WAS $99.95
$39.95
SAVE $60.00

IDE to SATA HDD Upgrade Panel

Clip this onto the end of an old IDE hard drive and the drive can then be used in our SATA docks or inside personal computers that lack IDE data and power connectors. A simple method for upgrading IDE drives. Compatible with: Maxtor, Samsung, IBM, Hitachi, Seagate Hard drives.

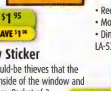


Dimensions: 120(W) x 25(H) x 62(D)mm
XC-4970 WAS $24.95
$14.95
SAVE $10.00

Security Accessories Savings

Large Alarm Sticker

For trucks, caravans, houses, offices and factories where a larger and more prominent deterent sticker is required.



- Sticks to outside of window
- Measures: 120 x 80mm

LA-5102 WAS $2.95
$1.95
SAVE $1.00

Oval Car Alarm Window Sticker

Ideal for cars & trucks and tells would-be thieves that the vehicle is protected. Sticks to the inside of the window and measures approximately 60 x 23mm. Packet of 2.

LA-5104 WAS $3.95
$2.95
SAVE $1.00

Dummy IR Camera

Visible deterrence is an important aspect of security. This dummy camera looks totally convincing - it has genuine-looking IR LEDs and a real LED that adds to the illusion. Add a couple of warning signs and your place looks like it has CCTV surveillance.

- Requires 2 x AA batteries
- Mounting hardware included
- Dimensions: 175(L) x 85(Dia)mm

LA-5325 WAS $24.95
$19.95
SAVE $5.00

Make Your Home Look Alarmed

No one will know that you don't have the full system. Looks like the real thing and the bad guys will move on to an easier target. Kit includes siren cover, strobe and alarm warning label.

LA-5130
WAS $49.95
$39.95
SAVE $10.00

Limited stock on sale items.
All Savings are based on Original RRP

www.jaycar.com.au

Jaycar Electronics
Better, More Technical

3.5" B&W Monitor Surveillance System

Quick and simple!

Consisting of a 5" B&W surveillance monitor, two cameras, and two dummy cameras, you can keep an eye on your premises. The real cameras simply plug in with their 10m lead, and the dummy cameras look identical. Great 'all round' package to get your surveillance requirements sorted, all for a great price.

- Monitor: 158(W) x 150(H) x 202(D)mm
- Cameras: 36(W) x 27(H) x 15(D)mm excluding stand & lens
- Camera stands are approximately 28mm high

QC-3446 WAS $169.00

$99.00 SAVE $70.00

B&W Bullet CCD Camera

This quality CCD camera is weatherproof for mounting under eaves, pools, driveways or pathway monitoring. Suitable for both professional and domestic installations. Supplied with a quality swivel mounting base and mounting hardware. Also ideal for low light level surveillance.

- Image sensor: 1/3" Sony B&W CCD
- Resolution: 510(H) x 492(V) 380 TV Lines
- Weight: 295g
- Dimensions: 89.5(L) x 28(Dia)mm

QC-3467 WAS $99.00

Limited Stock

$69.00 SAVE $30.00

Mini Portable Security Recorder

With a built-in sensor just connect this unit to a standard camera with composite video and the unit will record audio and video to an SD card. The AV input/output sockets connect to an external monitor (not included) for on-screen menu or use the front panel for full playback functions.

- 5VDC plugpack and AV cables included
- Requires 2 x AA batteries for portable use

QV-3094 WAS $349.00

Note: SD Card not included

$149.00 SAVE $200.00

Clip-On CCD Reversing Camera

Compact reversing camera with a variety of mounting options: number plate holder, flush or surface mounted, with screws or with double-sided tape (included). It also includes a bracket for mounting to roof racks on commercial vehicles.

- Camera size: 25 x 25mm

Limited Stock

QC-3729

WAS $249.00

$99.00 SAVE $150.00

RGB Video Balun

Send RGB up to 300m without signal degradation. Ideal for LCD projectors, monitors, plasma screens, etc. One required at each end. No power required.

- 3 x RCA to RJ-45 connectors.
- Video input: 1V p-p
- Bandwidth: DC to 8MHz
- Dimensions: 110(W) x 77(D) x 24(H)mm

QC-3429 WAS $79.95

Ideal for home theatre!

$24.95 SAVE $55.00

B&W CCD Camera in Metal Case with Audio

This camera utilizes a Samsung 1/3" CCD Image Sensor to produce high quality pictures, even in very low lighting conditions. The camera is supplied in a diecast metal case, and uses an onboard Electret Microphone for Audio and small metal mounting bracket.

- 380 TV Lines
- 92° lens angle
- Size 39(L) x 39(W) x 26(H)mm

QC-3474 WAS $69.00

Limited Stock

$49.00 SAVE $20.00

Rapport CCTV Field Tester

Designed with portability and the professional CCTV engineer in mind, this is an advanced piece of test equipment with a variety of functions. As well as performing multimeter functions, it will test the quality of a video image signal and display it on the 3.5" LCD.

- Rechargeable Li-Po battery
- CCTV video monitor
- Video signal generator
- Digital multimeter
- Input voltage: 12VDC
- Charging time: 6 hours

Multimeter specifications:

Dimensions: 88(W)125(H) x 40(D)mm

QM-3823 WAS $799.00

$749.00 SAVE $50.00

UHF Baby Monitor Transmitter

Partner this unit with one of our UHF transceivers and know exactly when your baby is awake, needs changing or feeding. With voice activation (VOX), whenever you're needed, you'll be alerted on the remote unit.

- Keypad lock to keep prying fingers out
- Rechargeable batteries and charger included
- 38 channel
- Up to 500m range
- Unit 140mm high

DC-1024 WAS $69.00

$20.00 SAVE $49.00

Colour Camera Kit with 2-Wire Connection

A simple 2 wire combined arrangement for power and video make this system a snap to install. The main unit will automatically sense signal cable tampering or incorrect wiring and alert you with a warning signal. Kit includes dome camera, system unit, 25m of connecting cable, and mains adaptor.

- CMOS sensor
- 360 TV lines

QC-3264 WAS $129.00

$69.00 SAVE $60.00

Also available:

Outdoor (IP56) IR Colour Camera Kit with 2-Wire Connection

QC-3266 WAS $149.00 NOW $89.00

SAVE $60.00

2MP Mini Digital Spy Recorder

The ultimate in discrete portable photo and video recording. From business meetings to outdoor sports activities - its applications are endless. Supporting up to 8GB of memory, it includes a 2GB MicroSD card, case, lanyard, two mounting brackets, software, USB and mains plugpack.

- High speed recording and fast response
- Low light recording
- Manual and sound activated recording functions
- Supports AVI & JPEG formats
- Rechargeable Li battery lasts for 2 hours of non-stop recording
- Measures: 55(H) x 20(W) x 28(D)mm

QC-8001 WAS $149.00

Waterproof Case

QC-8002 $39.95

$89.00 SAVE $60.00

Buy a Mini Digital Spy Recorder and receive a FREE Waterproof Case valued at $39.95

4 Channel Mobile DVR with 250GB HDD

This stand alone 12V, four channel digital video recorder (DVR) is the ideal solution for mobile security and surveillance applications. It provides real-time monitoring and digital recording for up to four cameras. Supplied with infrared remote and video editing software. MPEG4 recording format.

- 250GB HDD included
- Four camera inputs
- Analogue and VGA video output
- Motion detection recording
- Operating voltage 12 to 24VDC (suitable for cars, boats trucks and buses)
- Dimensions: 200(W) x 70(H) x 258(D)mm

QV-3093 WAS $1399.00

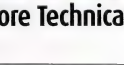
Massive Savings!

$599.00 SAVE $800.00

DOME Cameras on Sale!!!

Low Cost Colour Mini Dome Camera - Sharp Sensor

This tiny camera is excellent value for money and has specifications comparable to some higher priced dome cameras.



- 1/4" Sharp CCD Sensor
- 350TVL resolution
- Min illumination: 1 lux
- Lens: 3.6mm (92°)
- Dimensions: 72(dia) x 52(H)mm

Limited Stock

QC-3291 WAS $89.00

$59.00 SAVE $30.00

Colour CCD Dome Camera with Sony Sensor

A high quality colour CCD dome camera with 350TV line resolution and 1/3" Sony sensor chip. The camera features auto white-balance and shutter speeds from 1/50 to 1/100,000 of a second and is compact enough to be installed in the smallest of rooms or corridors. Requires a 12VDC regulated power supply.

- Dimensions: 108(W) x 81(D)mm dome-hemisphere

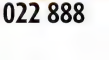
Limited Stock

QC-3318 WAS $179.00

$59.00 SAVE $120.00

Dome Style Colour CCD Camera

A high quality colour CCD dome camera with 480 TV Line Resolution, utilising a 1/3" Panasonic sensor chip. The camera features auto white-balance and shutter speeds from 1/50 to 1/100,000 of a second. Requires a 12VDC regulated power supply.



Limited Stock

QC-3498

WAS $279.00

$129.00 SAVE $150.00

All Savings are based on Original RRP

Limited stock on sale items.

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16 Channel Cable Identifier with DMM

Easily identifies individual conductors in a multi-core cable with just the remote unit attached to the other end. The remote unit has 16 numbered leads which are clipped to the cable being checked. Supplied with remote terminator, and multimeter leads.

- Autoranging DMM
- Diode & continuity test
- Auto power-off
- Case Included

QM-1329 WAS $79.95

$59.95
SAVE $20.00

Rechargeable Solar DMM

An environmentally friendly DMM with rechargeable batteries that can be charged from the built-in solar panel, 12-36VDC or from mains power. Never have to buy batteries again.

- Category: Cat III 600V
- Display: 2000 count
- Size: 179(H) x 88(W) x 39(D)mm

QM-1546 WAS $119.00

$79.00
SAVE $40.00

Sound Level Datalogger

Designed for recording and logging sound pressure level measurements for quality control, illness prevention, acoustic design or any other type of environmental sound measurement in domestic or industrial applications. Battery and windsock included.

- USB interface
- Over-range indication
- System requirements: Windows 2000, XP, Vista
- Dimensions: 140(L) x 28(W) x 21(H)mm

QM-1599 WAS $149.00

$119.00
SAVE $30.00

Cat IV Fixed Jaw Clampmeter

The ideal test instrument for electrical contractors. Compact and light with probe storage in the back for easy one-handed operation. Jaw opening is 16mm.

- Non-contact voltage sensor
- Data hold
- Auto power-off
- Display: 2000 count
- Dimensions: 190(H) x 62(W) x 42(D)mm

QM-1567 WAS $179.00

$109.00
SAVE $70.00

Autoranging SMT DMM

Specifically designed for SMT work with interchangeable probes and tweezer probes.

- Autoranging
- Continuity test
- Display: 6000 count
- CAT III 600V
- Dimensions: 110(H) x 36(W) x 21(D)mm

QM-1496 WAS $69.95

$39.95
SAVE $30.00

CAT IV Autoranging Pocket DMM

This pocket-sized DMM has features including detachable leads, capacitance, frequency and 1000V CAT III rating, which make it a serious test instrument.

- Large 4000 count LCD
- CAT III 1000V rated
- Built-in LED torch
- Non-contact voltage detector 100-600V

QM-1542 WAS $49.95

$34.95
SAVE $15.00

Trade Quality Cat IV 600V/ CAT III 1000V Digital Multimeter

A true RMS DMM purpose built for professional applications. With an ergonomic slimline yet robust design, it has overload protection, easy battery replacement, and comes supplied with a protective holster and test lead. A trustworthy instrument for apprentices and seasoned tradesmen alike.

- Display: 4000 count
- Category: Cat IV 600V
- Dimensions: 164(L) x 82(W) x 44(D)mm

QM-1623 WAS $199.00 Limited Stock

$129.00
SAVE $70.00

HDMI Cable Tester

Designed to check and troubleshoot the pin connections of Type A HDMI cables quickly and easily. It's ideal for testing the continuity of each signal pin of an HDMI cable prior to installation. Requires 9V battery.

- Carry case included
- Dimensions: 215(L) x 38(W) x 36(H)mm

AA-0406 WAS $149.00

$89.00
SAVE $60.00

Multifunction Water Quality Meter

Tests pH, temperature, total dissolved solids (TDS), electrical conductivity (EC), conductivity factor (CF) and oxidation reduction potential (ORP). The backlit LCD can display pH plus one other parameter at a time. If you've invested in a substantial aquarium setup, particularly a saltwater one, or recycle your own water, this instrument should be at the top of your shopping list. 9VDC mains adaptor, charger, buffer solution, probes with holder and carry case included.

- Dimensions: 208(W) x 200(H) x 76(D) mm

QM-1675 WAS $449.00

Also available:
Buffer Solution Refill pH 6.86
QM-1672 WAS $4.95 NOW $2.95 SAVE $2.00
Buffer Solution Refill pH 4.00
QM-1673 WAS $4.95 NOW $2.95 SAVE $2.00

$399.00
SAVE $50.00

Digital Capacitance Meter

High accuracy and extensive ranges to cover any requirement, zero adjustment display.

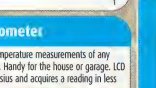
- 0.1pF to 20,000µF
- Holster included
- Banana to alligator clip leads

QM-1572 WAS $59.95

$44.95
SAVE $15.00

Flammable Gas Detector

When a flammable gas is detected, this unit will provide audible and visual annunciation via its in-built buzzer and LEDs. Simple to use and operate, it's perfect for checking gas bottles while camping or caravanning.



- Detectable gases: LNG and LPG
- Required 2 x AAA batteries (included)

QM-1660 WAS $69.95

$49.95
SAVE $20.00

Pocket Thermometer

Take quick and accurate temperature measurements of any surface without touching it. Handy for the house or garage. LCD displays temperature in Celsius and acquires a reading in less than two seconds.

- Handy pocket clip
- Batteries included
- Size: 85(L) x 15(Dia)mm

QM-7219 WAS $49.95

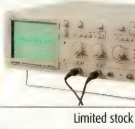
$29.95
SAVE $20.00

Oscilloscopes

40 MHz Dual Channel Oscilloscope (CRO)

This dual channel oscilloscope has a bandwidth of 40MHz and 1input sensitivity ranges from 5mV per division to 5V per division with a 'times 5' multiplier that increases sensitivity to 1mV per division. Allows you to view two separate input signals and display them either individually, alternately, chopped or added together.

The CRO has a number of trigger modes and will easily synchronise with TV sync pulses etc. Housed in a pressed steel cabinet that incorporates a folding stand, carry handle, and handy mains cable storage on the rear feet. The control panel is uncluttered and neatly laid out and the 135mm screen has an integrated 10mm square graticule. Display area measure 8 x 10 divisions. See website for full specification.



- Probes included

QC-1924 WAS $799.00

$649.00
SAVE $150.00

2 Channel USB Oscilloscope

Using the Plug 'n' Play USB technology and providing full optical isolation from the computer, this oscilloscope is easy to setup and use, as well as providing protection for the computer. The software is a fully featured chart recorder, function generator, logic generator, logic analyser, and spectrum analyser all in one easy to use package. See website for specifications.

- Oscilloscope, spectrum analyzer
- Sample rate: 100 Hz - 200 kHz
- Input voltage -20 - +20V
- ADC capacity: 10 bits

QC-1930 WAS $299.00

$269.00
SAVE $30.00

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USB Car Chargers

new

For anyone with a mobile phone or other device that charges from a USB socket, these are the perfect solution for recharging in the car. Simply plug into your car's cigarette lighter socket, and you have a readily available USB charging source. Two models are available: single and double sockets.

1.0A USB Car Adaptor

- Input: 10-18VDC
- Output: 5VDC, 1.0A
- Dimensions: 24(dia) x 52(L)mm

MP-3662 $9.95

3.1A Dual USB Car Adaptor

- Input: 10-18VDC
- Output voltage: 5VDC, 2.1A + 1.0A (3.1A total)
- Dimensions: 26(dia) x 60(L)mm

MP-3664 $19.95

FROM $9.95

3 x 10 LED Module

new

Small PCB fitted with 3 x 10 warm white LEDs. Designed for illuminating equipment panel displays and other small lighting applications.

- 12V

ZD-0491

$24.95

Car Charger for iPhone® / iPod®

$14.95
SAVE $5.00

Suitable for all versions of iPhone®, including the latest iPhone® 3G, and will charge different iPod® versions. Fitted with a curly cord, it will easily fit in a glove box without making a tangled mess of wires.

MB-3654 WAS $19.95

DC-DC Converter 5A with USB

new

This handy little device will convert 24VDC to 12VDC so you can use accessories designed for 12V vehicles. Has a USB output with 1A current to charge your mobile phone or other USB device.

- Maximum rated current: 5A
- Input voltage: 12-30VDC
- Output voltage: 12VDC
- Continuous output current: 4A
- Dimensions: 100(L) x 76(W) x 38(H)mm

MP-3354

$49.95

Steelmate Paging Car Alarm

This car alarm system minimises risk through it's coded disarm feature. It allows the owner to select a 1 - 5 digit pin code that is entered via the remote & is required to disarm the system. The alarm includes long range back-lit LCD paging remotes with integrated rechargeable lithium-ion batteries.

- FSK technology, range up to 3kms
- Active arming & passive arming selectable
- Valet mode
- Out of operating range warning

LA-9016 WAS $299.00

$249.00
SAVE $50.00

Car Kits - Build Them Yourself!

Car Battery Monitor

Don't get caught with a flat battery! This simple electronic voltmeter lets you monitor the condition of your car's battery so you can act before getting stranded. 10 rectangular LEDs tell you your battery's condition.

- Kit includes PCB board and all components.
- PCB: 62 x 39mm

KA-1683

$17.95

Voltage Modifier Kit

This kit intercepts and alters the signal from engine sensors that supply a voltage signal to the engine control unit (ECU). Restore correct air/fuel ratios after engine modifications, prevent engine boost cuts; or alter sensor signals for improved drivability. Requires hand controller for programming, RS232 cable and a suitable input signal. Kit includes PCB, case and electronic components.

KC-5490

Recommended with this kit:

Hand Controller Kit	KC-5386	$67.95
RS232 cable	WC-7502	$13.95

D.I.Y Kit

$79.95

Mixture Display Kit For Fuel Injected Cars

This kit will allow you to monitor the fuel mixtures being run by your car. This type of sensor is also known as an E.G.O. (exhaust, gas, oxygen) monitor. You can use it as a tuning tool, to help in vehicle modification or simply to see the behaviour of the engine control module. Indication is via 10 LEDs to show mixtures rich, lean and normal. The circuit connects to the EGO sensor mounted in the exhaust manifold and the cars battery.

- PCB, LEDs and components supplied.
- PCB: 74 x 36mm

KC-5195

$16.95

Thousands Sold!

Headlight Reminder For Cars

Nothing is more frustrating than getting into your car early in the morning, only to discover that you had left your headlights on the night before, running your car's battery flat. Features include a modulated alarm, ignition and lights monitoring, optional door switch detection, time-out alarm and a short delay before the alarm sounds. Build and install this hassle-saving kit and enjoy a feature in your car that many luxury vehicle owners have long taken for granted.

- Kit includes quality solder masked PCB with overlay, case with screen printed lid and all electronic components. 12VDC.
- PCB: 78 x 49 mm

KC-5317

$27.95

Courtesy Interior Light Delay Kit

Many modern cars feature a time delay on the interior light. It still allows you time to buckle up and get organised before the light dims and finally goes out. This kit provides that feature for cars which don't already provide it. It has a soft fade out after a set time has elapsed, and features much simpler universal wiring than previous models we have had.

- Kit supplied with PCB with overlay, and all electronic components.
- Suitable for circuits switching ground or +12V or 24VDC (car & truck with negative chassis.)
- PCB: 78 x 46mm

KC-5392

$19.95

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Arrival dates of new products in this flyer were confirmed at the time of print. Occasionally these dates change unexpectedly. Please ring your local store to check stock details. Prices valid to 23rd March 2011. All savings are based on original RRP

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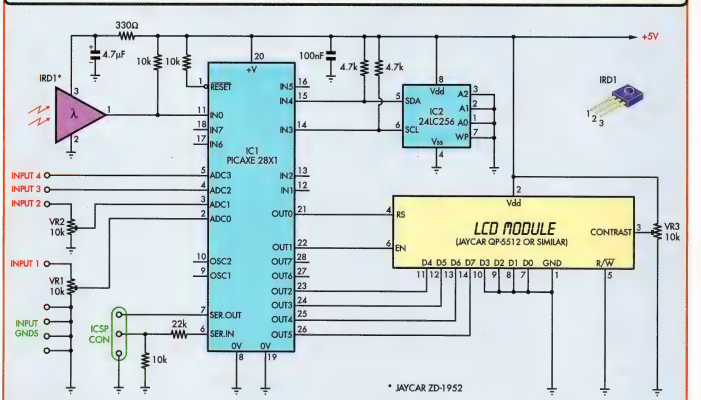
CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions from readers are welcome and will be paid for at standard rates.



PICAXE-based data logger

This circuit is a simple 4-channel data logger with infrared remote control and a 2-line LCD driven by a PICAXE 28X1 microcontroller (IC1).

Each channel has an analog input with 10-bit (5mV) resolution. The logged data is stored in a low cost 32KB serial EEPROM (Electronically Erasable, Programmable Read-Only Memory) IC (IC2). The channels are sampled at a configurable interval which can range from a few seconds up to about 18 hours. The logged data can be downloaded to a PC via a serial port.

The microcontroller communicates with the EEPROM IC using the 2-wire I^2C (Inter-IC Communications) protocol. Each reading takes up two bytes, so if all four channels are used, 4096 intervals worth of data can be stored.

The signals for analog inputs 1 and 2 can be attenuated using trimpots VR1 and VR2 respectively. This allows signals to be logged that may be in excess of 5V. Inputs 3 and 4 do not have such provision but it could be added if necessary.

While logging, the LCD displays the last readings taken and a countdown to the next reading. It is also used to display menu options which can be selected using a universal infrared remote control. The menu options include: start/stop logging, download data, clear data, change logging interval, apply scale factor to data, change number of channels, ADC input calibration and internal timing adjustment.

The software provided is set up to suit a Cobalt PLAU0067 remote control but can be changed to suit virtually any universal remote. The easiest way to do this is to uncomment the line which causes the logger to immediately go to the infrared keycode checking routine when power is applied. This displays the code for each button press on the LCD and this code can then be programmed in for future use.

Data is downloaded to a PC using the in-circuit serial programming (ICSP) header. This interface does not support RS-232 signal levels so it may not work with some serial ports but most USB-to-serial port adapters should be suitable. The serial port on the PC must be set up as 9600 baud, eight data bits, no parity bit, one stop bit (9600-8-n-1). Hyperterminal or other similar software can be used.

The software (PICAXE_Data_Logger.bas) is available from the SILICON CHIP website.

Phillip Webb,
Hope Valley, SA. ($45)

Editorial comments: the ADC0-3 pins of IC1 could be damaged if a voltage outside the range of 0-5V is applied to an analog input with a low source impedance (depending on the positions of VR1 and VR2). It is good practice to insert a series resistor of 2.2-4.7kΩ between each analog input and the signal source to limit fault currents to a safe level.

Sinewave oscillator has low distortion

This circuit generates a sinewave at 30Hz-72kHz with around 0.001% (-100dB) total harmonic distortion plus noise (THD+N). The output amplitude is adjustable over a range of about 0-2V RMS and a second output is provided for connection to a frequency counter.

At its heart is a Wein bridge oscillator, driven by JFET-input op amp IC1a (half of an OPA2134). The frequency range is selected with a 2-pole, 3-way switch which connects different sets of capacitors to the bridge. The options are 30-720Hz (with the switch as shown), 300Hz-7.2kHz and 3-72kHz. Fine frequency adjustments are made using potentiometer VR1, a dual-gang linear type.

With a traditional Wein bridge oscillator, one end of the bridge is connected to ground. Instead, in this circuit it is driven from IC3a's pin 1 output. This keeps the sinewave symmetrical about ground, reducing the common mode distortion from IC1a (see Linear Technology application note AN43 for more details).

The resulting waveform is attenuated by potentiometer VR3 and then buffered by op amp IC1b. It is AC-coupled and further attenuated (by 0, 20 or 40dB) according to the position of switch S2. The output impedance is between 9Ω and 90Ω depending on the position of S2. The frequency counter output is buffered by a simple NPN emitter-follower and then AC-coupled to CON1.

The key to low distortion is the optical amplitude stabilisation. The generated sinewave is also applied to the non-inverting input (pin 3) of op amp IC2a. IC2a and IC2b, in combination with diodes D1-D2 and some resistors, form a precision rectifier. Its output is fed to a low-pass RC filter comprising a 1kΩ resistor and 4.7μF capacitor with the resulting voltage tracking the average amplitude of the sinewave.

This voltage drives a voltage-to-current converter consisting of a 10kΩ resistor and op amp IC3b. Since IC3b's non-inverting input (pin 5) is tied to 0V, as the sinewave amplitude rises, IC3b sinks more current, keeping its inverting input (pin 6) at 0V. As the current increases, so does the voltage drop across the 10kΩ resistor. Therefore, the current through LED1 is proportional to the sinewave amplitude.

LED1 emits white light and is optically coupled to light-dependent resistor LDR1. This is accomplished by filing its lens flat, placing the LDR in direct contact with it and using black heatshrink tubing to hold them close together. This tubing also prevents outside light from reaching the LDR.

As LED1's brightness increases, LDR1's resistance drops (see graph), reducing the gain of the amplifier involving op amp IC1a. This negative feedback means that the amplitude reaches a steady state since any further increase would only reduce the amplifier's gain.

For the circuit to oscillate, the closed loop gain must be three. The gain is determined by the minimum current through LED1, the corresponding resistance of LDR1 and thus the gain of the amplifier built around IC1a.

Alex Sum is this month's winner of a Peak Atlas Test Instrument

In this case, the minimum LED current is 1mA, as set by 4.7V zener diode ZD1 and the 4.7kΩ resistor, which form a simple current source. Referring to the graph we can see that LDR1's minimum resistance is just over 2kΩ. The gain with LED1 at 1mA is the total resistance of VR2 and LDR1 divided by 1.5kΩ. So stable oscillation will be obtained with VR2 set to around 2.5kΩ. Small changes to the position of VR2 will result in changes in the stable sinewave amplitude.

Ideally, the capacitors in the Wein bridge network should be selected from a large batch, using a capacitance meter. Polypropylene or polystyrene capacitors will result in lower distortion than polyester types due to their better linearity. In addition, the oscillator stability will also benefit from the use of a good-quality dual-gang pot with accurate tracking for VR1 (eg, conductive plastic or Cermet types).

The power supply provides regulated ±12V rails from four 9V batteries. The regulators could also be fed from rectified and filtered 12VAC from a mains transformer or plugpack. It is also possible to run the circuit from ±9V or ±15V (the latter may result in slightly lower distortion).

Alex Sum,
Eastwood, NSW.

Editorial comments: for the 90Ω and 900Ω resistors, constructors can use two or more standard value resistors in parallel (eg, 91Ω || 8.2kΩ and 910Ω || 82kΩ).

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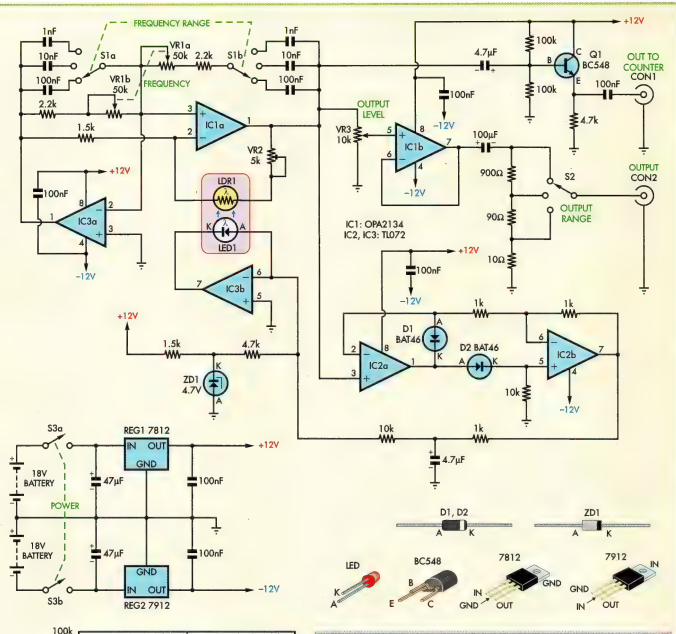
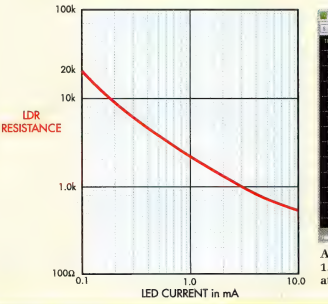
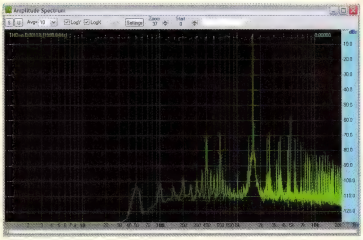
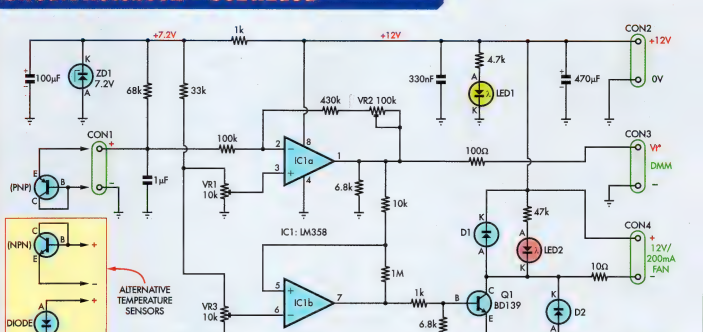






Above: this graph shows a plot of the frequency spectrum of a 1.5kHz sinewave. The distortion is mostly third harmonic and at .0011% THD+N it is just 11 parts per million.



Using transistors to measure temperature

Since a transistor's base-emitter voltage varies with temperature, it can be used as a thermometer. Diodes can also be used for the same purpose. This circuit shows how a transistor such as the BC549 (NPN) and BC559 (PNP) or diodes like the 1N4148 and 1N4004 can be used to switch on a fan at a specific temperature.

Each junction has different characteristics so the circuit incorporates several adjustments to allow it to be trimmed to suit a particular device. The selected device is connected to CON1 and a 68kΩ resistor from the +7.2V rail drives about 0.1mA through it.

The voltage developed as a result of that current (typically 0.5-0.6V) is filtered by a 1µF capacitor and is fed to the inverting input, pin 2, of op amp IC1a. The base-emitter (or diode) voltage is reduced as temperature rises but we want an output that increases with temperature, so op amp IC1a is configured as an inverting amplifier. It subtracts the base-emitter voltage from a reference voltage supplied by trimpot VR1 to its non-inverting input (pin 3). IC1a then amplifies the difference between the voltages according to the gain set by trimpot VR2.

Normally, trimpots VR1 & VR2 would be set so that the temperature coefficient of the output voltage from IC1a is 10mV/°C. So for a temperature increase of 50° C, for example, the output voltage would increase by 500mV.

Since the temperature coefficient of P-N junctions is usually around -2mV/°C, the gain of IC1a needs to be set by trimpot VR2 to about -5. With the values shown, the adjustment range is -4.3 to -5.3.

Once calibrated, the output at CON3 is typically accurate to within ±5°C over a range of about 0-100°C.

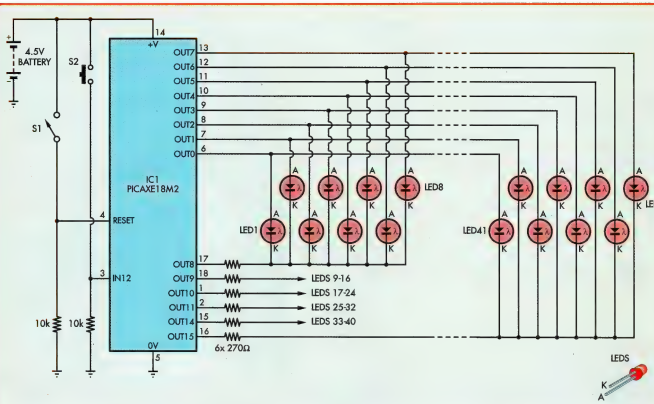
The output voltage of IC1a is also applied to the non-inverting input (pin 5) of op amp IC1b which is configured as a comparator, to act as a thermostat. The voltage at the inverting input (pin 6), is set by trimpot VR3 and has a range of about 0-0.83V (0-83°C).

When the temperature exceeds this threshold, the output of IC1b goes high, turning on NPN transistor Q1. This allows current to flow through a small 12V fan (or a 12V piezo buzzer, etc) connected to CON4. When Q1 is on, LED2 is lit. Diodes D1 & D2 absorb any inductive spikes or back-EMF from the fan motor. The 1MΩ resistor between pins 5 & 7 of IC1b provides hysteresis to prevent rapid switching at the threshold.

The supply voltage is nominally 12V but can be up to 15V, allowing operation from a 12V battery or similar supply. The +7.2V reference is derived from the main supply using ZD1, a 1kΩ current-limiting resistor and a 100µF filter capacitor.

To calibrate the circuit, attach the sensor to CON1 and place a DMM across CON3 (in Volts mode). Adjust VR1 so that the DMM reads 0V at room temperature. You will need to measure the room temperature and note it.

Next, heat a bowl or saucepan of water so that it is at least 30°C above room temperature, as measured by the same thermometer. You then use the PN junction sensor to monitor



PICAXE-based 48-LED chaser

This circuit uses the new PICAXE-18M2 chip to create a 48-LED light chaser. The 18M2 has 14 digital outputs and these are all used to drive the LEDs.

A switch (S1) and a pushbutton (S2) are connected to the two remaining pins, which can only be used as inputs. These could be used to control the chaser pattern although the sample software provided only implements a simple chaser pattern. More complicated patterns can be made by changing the software and S1 or S2 could be used to select between several different patterns.

The LEDs are arranged in six groups of eight. Each group has a common cathode driven by one of the OUT8-OUT11 or OUT14-15 pins. For each group of eight LEDs there is a common 270Ω current-limiting resistor at the cathode end.

The anodes of each group are driven by pins OUT0-7. The LEDs can be lit individually despite sharing the anode pins with five other groups because only one set of cathodes is driven low at any one time.

When a cathode is not being driven, it can either be held high or set to high impedance. Similarly, anodes which are not being used can either be held low (0V) or set to high-impedance mode (ie, configured as an input). In some cases, one or more LEDs may be reverse-biased but no current will flow since the reverse voltage is below 5V.

Pins 2 & 3 of IC1 are typically used for in-circuit serial programming but in this case, pin 2 is used to drive one of the common cathodes. As a result, it will be necessary to use a switch to disconnect that pin from the LEDs if you wish to add an in-circuit programming connection.

It is possible to modify the software so that multiple LEDs can light at one time but if you do, be sure to check that the per-pin or total current limits for IC1 are not exceeded. Also, if multiple LEDs from a single group are lit at once, it will affect their brightness since they share current-limiting resistors.

Two sample programs for this circuit are available from the SILICON CHIP website (LED_Chaser_18M2.zip).

S. Grundy,
Otago, New Zealand. ($45)

the water temperature and adjust VR2 to set the gain. For example, for a temperature that's 30°C above ambient, adjust VR2 to give 300mV. VR1 is then readjusted so that the reading equals the actual water temperature multiplied by 10mV, eg, for a water temperature of 50°C, the reading should be 500mV.

Finally, determine the temperature (in degrees Celsius) at which to switch on the fan (or other load) and multiply this by 10mV. Connect a multimeter between pin 6 of IC1b and ground and adjust VR3 to get the required reading.

Petre Petrov,
Sofia, Bulgaria. ($40)

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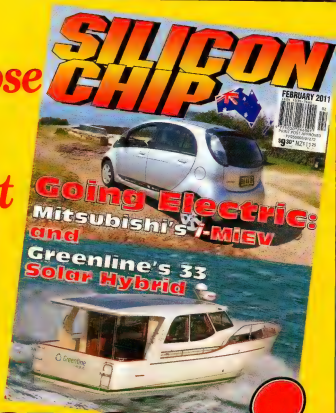

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Do you have excessive mains voltage at your place? In some parts of Australia the mains voltage can be above 250VAC and that can spell early death for imported appliances rated to work on only 220VAC. In this article we show you how to reduce the mains voltage to a safe level for your equipment.

by Leo Simpson

Despite most people *still* believing Australia's mains voltage is 240VAC (we get emails and letters telling us we're wrong!) according to Australian Standard AS:60038 the "official" mains voltage is 230VAC – and has been for more than a decade.

However, in many parts of Australia the supply ***is*** still nominally 240VAC; indeed in parts of Western Australia and many mining towns it is even higher at around 250VAC – and sometimes even more.

There are several reasons for this but primarily it's because a higher voltage is fed into the network at the substation so that at the end of (often very long) supply lines, with their inevitable I^2R losses, there is sufficient voltage to do the work required.

That's fine if you are at the far end of the line but if you're at the near end, you cop that excess voltage. It's long been the bane of people with incandescent light globes (the globe life is dramatically reduced) but now that the government has banned those globes, that problem obviously would have gone away. (Oh yeah? Believe that and I have this big steel bridge over Sydney harbour that I can sell you real cheap!).

220V equipment

Problems caused by excess voltage have been the case for many years but with so much imported electronic equipment, rated for only 220VAC, there is a big problem of reduced reliability at those elevated voltages.

The higher voltage can be a problem for two reasons: higher power dissipation and greater risk of catastrophic breakdown.

For example, if your equipment is rated for an input voltage of 220VAC and it is actually being fed 250VAC, that amounts to a 13.6% increase in voltage. But because power, for typical loads, is proportional to the square of the voltage, the increase in power dissipation over the rated voltage is up to 29%.

That's a very large increase and if you are in an area where the ambient temperature regularly tops 40°C or more, that can mean that your equipment could easily expire.

Even if your mains voltage is around 240VAC, that still represents an increase in power dissipation of 19% (compared to running at 220VAC) which is still pretty significant, especially in equipment which has a tendency to run hot even at its rated input voltage.

Reducing dissipation

Maybe you don't have a problem with the level of the mains voltage itself. But there is another good reason to run a key (expensive!) appliance such as a large screen TV or such like from a lower voltage: it reduces the internal power dissipation and therefore causes it less stress – which in turn should prolong its life.

Either way, the method we are describing for reducing the mains voltage is the same; using a step-down transformer.

More specifically, we are going to show how to connect a step-down transformer as an "auto-transformer". While this allows the input voltage to be reduced, it does not provide any voltage isolation between the input and output as does a normal transformer.

However, first we need to emphasise the point about electrical isolation.

If you connect an appliance via a conventional step-down transformer with completely separate primary and secondary windings, there will be electrical isolation between the 230VAC mains supply and the circuity of the appliance, making it "safer" to work on if you are doing a repair.

But no such isolation is provided when you connect an appliance to the 230VAC mains supply via an auto-transformer.

The answer to this problem is simple: always assume a circuit, any circuit, is dangerous unless it is unequivocally proven otherwise!

Our Mains Moderator

So for the purpose of this article, we decided to take a readily available step-down transformer with a range of secondary voltage taps and show how to connect it to reduce 250VAC to 220VAC (or pretty close to that figure). Also for the purpose of this article, we decided to limit the power of our notional load to no more than 450W.

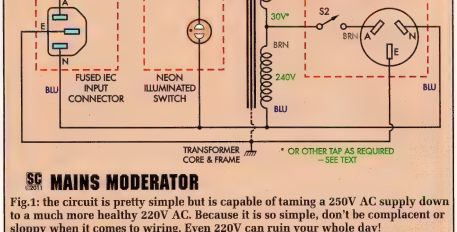
Typical examples of electronic equipment which would be under this power limit would include most large screen plasma and LCD TVs and video monitors, most PCs and most audio amplifiers. If in doubt about how much power an appliance uses, check the nameplate or failing that, the owner's handbook.

The reason for the limit of 450W is that we wanted to use a small transformer rated at 60VA, with a multi-tapped secondary.

This type of transformer is commonly available (eg, from Altronics [Cat M-6674L] or Jaycar [Cat MM-2005]). They have a number of secondary voltage taps between 9V and 30V and the rated secondary current is 2A.

That last figure is significant because it sets the maximum power of the appliance we want to drive. To explain this point, if you have a 450W appliance rated for a 220V input, its nominal current drain will be 2.045A; close enough to 2A as to be an insignificant difference.

The transformer is wired as shown in the diagram of Fig.1. In this case,



SC 2011 MAINS MODERATOR

Fig.1: the circuit is pretty simple but is capable of taming a 250V AC supply down to a much more healthy 220V AC. Because it is so simple, don't be complacent or sloppy when it comes to wiring. Even 220V can ruin your whole day!

we have shown the full 30V secondary winding connected in series with the 240V primary winding of the transformer. In effect, this gives a 270V primary winding and we "tap off" the output across the 240V winding, giving a step-down effect.

Now, if 250VAC is applied to the input, via the IEC socket, the output will be 250/270 x 240 = 222V. This would be ideal if you have a 220VAC appliance and your mains voltage typically hovers around 250VAC.

Alternatively, if your mains voltage is typically around 240VAC or a little more and you want to reduce it to around 220VAC , you would use the 20 or 21V secondary tap of the transformer, giving a ~261V total primary winding, with the same output connections as before. In this case, the output will be 240/261 x 240 = 220.7V.

Transformer current

We mentioned previously that we wanted to use a standard transformer with a 2A multi-tapped 30V secondary. This would set the limit on the maximum load. And while the current of a 450W 220V appliance will nominally be 2.045A, the current drawn from a 250VAC mains supply will be somewhat less. To be precise, it will be 240/270 x 2.045 = 1.82A. (This assumes an "ideal" transformer with no quiescent magnetising current).

This current will flow in the transformer's 30V secondary and while it is less than the 2A rating, it will be somewhat more than 1.82A because we are using a "real" transformer with its associated losses. Hence, to run a 450W 220VAC load, the suggested transformer will actually be running fairly close to its maximum ratings.

In theory, you could apply the same method to drive a much bigger load. So if you had a 250VAC mains supply and wanted to drive a 1000W 220VAC load, with a nominal current of 4.5A, you would choose a transformer with a 30A 5A rating (ie, 150VA or more) and connect it the same way as shown in our diagrams.

By the way, we mentioned incandescent globes earlier; this project would be ideal for them (up to the 450W rating, of course).

Unsuitable loads

While we are suggesting this auto-transformer connection to drive electronic appliances, we are not recommending it for any heating or motor-driven appliances such as power tools, fridges, freezers and so on. The main reason for this caution is that motor driven appliances typically have very high starting surge currents which will overload the transformer.

Wiring it up

We installed our demonstration unit in a sealed plastic IP65 case measuring 171 x 121 x 80mm (Jaycar Cat HB-6254).

With the exception of the transformer (which is earthed) everything is mounted via Nylon 3mm screws and nuts, for safety.

Ensure that the earth lug under the

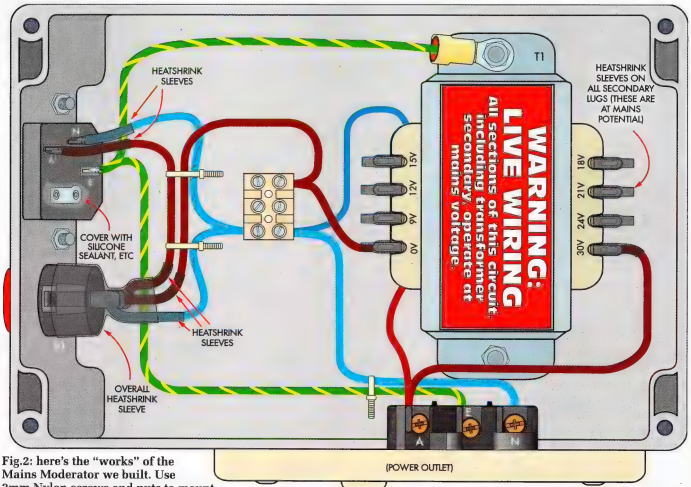


Fig.2: here's the "works" of the Mains Moderator we built. Use 3mm Nylon screws and nuts to mount everything except the transformer (which is earthed). If you wish to use a different transformer tap to achieve a different output voltage, move the wire connected to the 30V tap ONLY (ie, leave the 0V tap where it is!).

And here's the internal photo While the wiring in this photo is correct, you should find it a little easier to follow that in the diagram at left. Don't take any shortcuts with insulation and wiring dress – it is still a mains device after all.

mains transformer screw makes good contact with the transformer body by scraping away any passivation which may have been used on the body.

We used a fused IEC male chassis connector (screw mounting, not snap-in) mounted on the end and a standard single 240V switched GPO (power point) mounted on the side of the case.

Also included was a 250VAC 10A SPST switch with inbuilt neon illumination and a short length of insulated terminal strip to terminate some of the wires.

A length of 3-way terminal strip is used simply to allow two mounting holes – one position is unused.

You will need to make cut-outs in the case for the IEC socket and the switched GPO (general purpose outlet) as well as drill holes for the SPST switch, transformer mounting feet, rubber feet for the case, two holes for the insulated terminal block etc. We mounted the switched GPO so that its two securing screws are attached to the bottom section of the case – see the photos. Note that you will need to make irregular cut-outs in the top and bottom sections of the case to clear the rear terminal section of the switched GPO.

The SPST switch requires a 20mm mounting hole with a small notch on the right-hand side. It is a snap-in mount switch and you may need to slightly chamfer the inside of the 20mm hole to allow the snap-in lugs to lock properly into place.

All the wiring details are shown in Fig.2 and note that all wiring is run in 250VAC-rated wire.

Let's just briefly summarise the main points of the wiring, assuming that all the hardware items have been installed in the case.

(1) A brown wire is run from the Active terminal of the IEC connector to the top zinc-plated terminal of the SPST switch. Then a brown wire is run from the centre terminal of the switch to a connector on the insulated terminal strip. This same terminal also connects to the 0V secondary tap on the transformer.

(2) Another brown wire runs from the 30V terminal on the transformer to the Active (A) connection on the switched GPO. This same connection also terminates the brown wire from the 240V primary of the transformer.

(3) A blue wire is run from the Neutral terminal of the IEC connector to another terminal on the insulated terminal strip (leave one terminal between Active and Neutral unused).

(4) This Neutral terminal is also used to terminate the blue wire from the 240V secondary of the transformer and a blue wire to the Neutral connection on the switched GPO.

(5) As well, you need run a blue wire to the third (brass-plated) terminal of the SPST switch. This is necessary to power the inbuilt neon lamp.
(6) Once the wiring to the SPST switch is complete, it should be fitted with a suitable length of heatshrink sleeving to shroud the whole assembly.
(7) On the same theme, as each wire is soldered, it should have a short length of 5mm heatshrink sleeving applied. The exceptions to this are the two green/yellow wires which terminate at the Earth terminal on the IEC connector.
(8) One of those green/yellow wires earths the frame of the transformer while the other runs to the Earth connection on the switched GPO.
(9) All the unused terminals on the transformer should be fitted with short lengths of heatshrink sleeving. Use short cable ties to anchor the wiring, as shown in the photo and diagram.
(10) Finally, there is an exposed mains metal strip on the back of the IEC input socket (it connects the Active pin to the fuse). For maximum safety, cover this with insulation – preferably, a thin bead of silicone sealant.

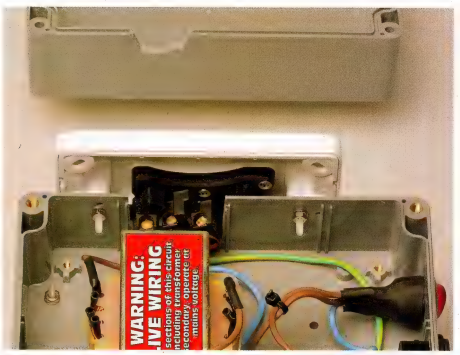
When all your wiring is complete, check it very carefully against the photos and the diagram. Then fit a 2A fuse in the IEC connector and insert an IEC power lead. Do not connect any load to the GPO. Apply power and switch on. The neon should illuminate. If not, disconnect the IEC power lead and find your mistake.

If the neon did light up, you can then use your multimeter to check that the transformer is wired correctly to reduce the mains voltage.

It is possible that you may find that the transformer is actually boosting the voltage rather than reducing. This is not necessarily an error on your part but can be because there is no convention as to how mains transformer primary and secondary windings are phased.

So if your mains voltage is around 250VAC, for example and you have wired the transformer as shown in this article, then the output voltage at the switched GPO should be close to 220V.

If, on the other hand, the output voltage is closer to 270VAC, then you should switch off, unplug the IEC power lead and swap over the 0V and 30V wires from the secondary of the transformer. Now try it with a load connected and everything should be working correctly. As we mentioned earlier, an incandescent light globe, mains rated of course (say about 60W or so), is ideal as a load for checking.



You're going to have to perform a bit of minor surgery on the side of the case (both top and bottom) to accommodate the power outlet, along with the holes in the end for the IEC mains input connector and the neon switch. Note how the power outlet mounts low down on the side of the case (not in the centre!) to give its mounting screws something to hold onto.

Parts List – Mains Moderator

1 IP65 case measuring 171 x 121 x 80mm (Jaycar HB-6254).
1 9-30V, 60VA 2A multi-tapped transformer (Jaycar MM-2005)
1 male chassis IEC connector with integral fuseholder
1 M205 2A fuse
1 IEC mains lead with 3-pin plug
1 single switched mains outlet
1 red neon illuminated SPST switch (Jaycar SK-0962)
1m 3-core mains flex
1 3-way 15A mains-rated insulated terminal block
1 5mm crimp-type eye lug (earth connection to transformer)
4 rubber feet
Heatshrink sleeving
3 100mm cable ties
1 transformer warning label

Screw and nuts

10 Nylon M3 x 15mm screws, nuts and shakeproof washers (to mount IEC socket, insulated terminal block, GPO and rubber feet)
2 M4 screws, nuts & shakeproof washers (to mount transformer)

No misteak misstake error!

Finally, we should make a couple of points. You may wonder why we refer to the "240V" primary of the transformer and to "250VAC" ratings when we made such a point of the official mains voltage in Australia being 230V.

It is not a mistake, nor a contradiction – it's simply because that is how transformers are labelled (manufacturers have been a bit slow to catch up!).

Also, throughout this article we have referred to a switched GPO. GPO is "electrician talk" for General Purpose Outlet. Mere mortals know them as "power points".

We deliberately used a single outlet, rather than the doubles more commonly available (and usually cheaper!), to minimise the risk of someone – who didn't realise the significance of, or reason for, the circuit – plugging in something "extra" and exceeding the 450W rating.

If you had a specific application you could, of course, use a double outlet but bear our reasoning in mind. SC

Salvage It!

BY NENO STOJADINOVIC

A Vacuum Pump from Junk

Every young techie needs a vacuum pump. They rate alongside the air compressor, multimeter and soldering iron as one of the most useful tools to take their place in the arsenal. This guide will show you how to make a serious vacuum pump for next-to-nothing. Add a vacuum tank for much the same price and you are loaded for bear.

It used to be that every young scientist needed a vacuum pump. There was metal to sputter, glass envelopes to evacuate when producing X-ray tubes and investment to 'de-bubble' when making castings.

Nowadays, there are commercial products available to replace these venerable old staples but hobby scientists have compensated by expanding the scope of their activities.

I don't sputter my own telescope mirrors but I do pot my own coils and ultrasonic transducers and use vacuum to remove all air bubbles from the resin.

I don't make X-ray tubes but I do make robot parts with 'prepreg' carbon fibre that uses a process called vacuum bagging to mould the material.

And call me funny but I find a strange fascination with the science of refrigeration. In refrigeration systems the flow rate and pressure can be considered analogous to current and voltage in electronic circuits.

With the advent of LP gas as a refrigerant and cheap manifold gauges, I find a lot of tech heads like me sitting around watching ice form on their home made evaporator coils.

Where do you get it?

Vacuum pumps live in the bottom of every refrigerator, except they are cleverly disguised as refrigeration compressors. Countless refrigerators are thrown out due to gas leaks, faulty thermostats or some other minor fault, leaving a perfect compressor that is just ripe for a new purpose in life. Refrigeration compressors of this type are commonly referred to as "sealed units", and are a simple piston pump running in an oil bath for longevity.

Liberating the compressor is simple enough but it needs to be approached with a bit of caution. Most discarded fridges I've seen are devoid of gas but the gas lines can possibly be still under pressure and may also be partly full of refrigeration oil. Thus it is important to put on goggles before you begin, and don't point the pipes at yourself as you're cutting them.

So to begin: peer under old fridges until you find a compressor that doesn't have capacitors near it. (It's not difficult to drive a capacitor motor but there are plenty available that don't use them at all, so I avoid the capacitor jobs as a needless complication).

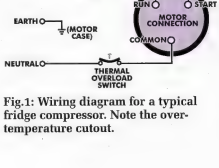


Fig.1: Wiring diagram for a typical fridge compressor. Note the over-temperature cutout.

Cut all of the gas lines to the compressor, leaving a handy length to work with. Use a pair of side cutters or a tube cutter to sever the lines, as a saw will introduce fragments of metal into the compressor.

Cut the electrical connections, unbolt the compressor and the prize is yours!

Test drive

Firstly, find out if it runs. Most simple compressors use a split phase start winding which is energised by a solenoid that is connected in series with the main, or "run" winding.

When the motor is first started, the main winding draws a large current. As the solenoid is connected in series, the heavy current creates a magnetic field that pulls the contacts shut and thus energises the start winding. As soon as the motor is up to speed, the current in the main winding dwindles and the solenoid drops out, thus cutting off power to the start winding. Hopefully, fig.1 should make it all clear. Once you've got it wired up, just stand back and plug it in.

Quiet fridge-type hum good, flames bad!

Once you have a good one up and running, partially block the thick pipe near the top of the compressor. You should feel a bit of suction but don't

MAINS EQUIPMENT
Take extra care when salvaging any old 240VAC mains equipment. Be aware that insulation may have broken down, previous repairs may be "dodgy" ...and mains voltages can kill. Remember that old adage: "If in doubt, don't!"

block the pipe completely, because if you do, the compressor oil will froth up inside the housing and then squirt violently out of the other pipe.

If all is well, power it all down and get cracking to change the oil.

The oil is drained by undoing the service plug and just letting it pour out. Of course, we don't have to say that it must be disposed of properly . . .

Once it's all gone, the compressor can be refilled by pumping the new oil into the vacuum (thick) pipe.

It is possible to get many different grades of vacuum oil, mostly selected for intended vacuum level and type of pump, but for most jobs I use standard air compressor oil.

It is available at most places that sell air compressors and comes in a handy squeeze bottle that allows you to partially fill the compressor before your wrists give out.

Then you can use the compressor itself to suck the rest in – just block off the service port and stick the vacuum pipe into the oil bottle. Stop the pump every now and again to check if the oil level has reached the level of the service plug and once it's oozing out you are done.

Here's what you're looking for. It almost certainly won't look as pristine as this (in fact, it will probably be at least a bit rusty and/or covered with grease and dust). But most fridges these days have a compressor looking something like this one.

Pull Vacuum

Vacuum pumps require you to learn a new vocabulary and some new physical principles. First of all, if you convince all of the air molecules in a container to vacate the premises, you will have yourself an absolute vacuum. The gauge pressure, relative to atmosphere, will be -101kPa or -14.7psi if you're over 45 years old. Americans will say -30in Hg, while Europeans will say minus one bar or possibly -760mm Hg.

I buy little vacuum gauges on eBay (see Fig.5) and they can tell you that the typical home-made vacuum pump will pull better than -25in Hg if allowed to run for a while.

Remember that below certain vacu-

Fig.2: a compressor with the lid cut off. Gas enters the stub of pipe near the bottom of the figure and exits through the long thin pipe that loops across the top. This pipe always exits into an equally thin pipe on the outside of the housing. The compressor is normally suspended from three springs but these are disconnected in the photo.

Fig.3: the casing itself. The loop at the bottom is a heat exchanger and leads out to two thin pipes near the bottom of the casing. Gas is drawn directly into the casing and the inlet port can just be seen at the top of the figure. Inlet gas is hot and not very dense so it always flows through large diameter pipe. The service port can be seen at right.

Fig.4: a reservoir tank made from a 9kg gas bottle, adapted to a standard air line fitting. It is worth knowing that most pipe fittings in Australia have a BSP (British Standard Pipe) thread. This includes air lines, refrigeration, plumbing, irrigation, etc so it is fairly well universal. BSP fittings will even screw into most American (NPT) fittings. Note though that gas lines use a tapering thread (BSPT) while most other pipes use a parallel thread (BSPP).

um levels you are not so much pumping air as convincing air molecules to float into your pump.

Once it's all up and running, I like to solder a hose barb onto the vacuum line to suit the job at hand, perhaps build it into a handy tool box so I can carry it around, all nice and neat.

Note that standard compressed air hoses and fittings work just as well under vacuum as they do under pressure.

You will find that the pump ejects an oil mist while it's running. I catch the oil in a can and run a hose to the vacuum line so I can draw the oil back in once a bit has collected.

Care and feeding

First and foremost, don't ever use your vacuum pump as a compressor. You will inevitably draw impurities into the pump while it's on evacuation duty and some of them can be explosive when subsequently in contact with compressed air.

And following on from that, vacuum pumps will be damaged if you allow them to suck up crud. The cure is to use a separator. They are commonly used in distillation (especially the moonlight kind) so look them up or else drop me a line and I'll show you how to build one out of an old Primus bottle.

If you want to suck up large quantities of liquid, dust etc, it is best to use a large vacuum tank as a reservoir. Old gas bottles can be found at most dumps, and it is a simple matter of buying a matching fitting to convert it to a vacuum tank – see Fig.4.

Places that sell barbecues are a gold mine of fittings, valves and hoses that can be re-purposed for our warped needs. Once you've evacuated the tank, you'll be amazed at the sheer power of a measly one bar of (absent) air.

Politically correct message about refrigerant

Most of the fridges I've seen at the local dump have been very obviously empty of gas; it seems nobody treats malfunctioning whitegoods very well and broken pipes are common. I even found one that was riddled with bullet holes!

It is environmentally unfriendly and illegal to release refrigeration gas to the atmosphere, so if you can't find a 'pre mauled' unit, the next best thing is to go and visit your local refrigeration mechanic. Refrigeration repair is yet another industry that has been hit hard by cheap imported goods and many people lug in a fridge only to be told that a repair would cost more than a new one.

Fig.5: you'll find many vacuum gauges on eBay, new and used, ranging from next-to-nothing to next-to-ridiculous. This one, for example, was brand new and about $25 plus postage. Most common are the combined vacuum/boost gauges intended for automotive use – they're fine for our purposes and often the cheapest (sometimes <$10).

Suddenly you have a fridge waiting for you and the mechanic will suck all of the gas out for a small fee.

Even better is that mechanics are generally friendly folks and have all sorts of goodies for the likes of us. How about a 12V fridge compressor? (They are very common in caravan units).

Or else maybe a complete condensor unit? They are those boxes that you see on the sides of buildings used for coolrooms and split system air conditioners, and they are full of goodies. I got a working unit for $10. SC

WARNING: Use a full face shield when evacuating glassware. Glass will eventually weaken and implode when subjected to vacuum, causing shards to explode outwards.

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12V 20-120W Solar Panel Simulator

By JOHN CLARKE

How do you test or develop a solar charge controller such as the unit described in SILICON CHIP last month? You could use a solar panel but then you are at the whim of the weather and time of day. Also you would need several panels of different sizes to test it properly. This device solves all those problems.

THIS SOLAR PANEL Simulator allows charge controllers to be tested without a solar panel. A simulator is handy because a solar cell panel will not always provide power and will certainly not deliver its full power output at all times.

It is only around noon on a sunny day that the solar panel will deliver its rated power. In other conditions (eg, cloudy days), the panel delivers less than full power, while at night it will not deliver any power at all and may even draw power from the battery (unless precautions are taken).

So when the Sun is not shining, an alternative source of power is necessary if you wish to test a charge controller such as the SILICON CHIP unit described last month. This is where this Solar Panel Simulator comes in handy. It can not only deliver power when required but can also deliver full power for as long as is necessary, regardless of the amount of sunlight.

Typical system

Solar panels are becoming increasingly popular for charging batteries and supplying power to equipment where mains power is not available. A typical system comprises the solar panel, a solar charge controller and a battery. The charge controller ensures that the battery is correctly charged and is a necessary part of the system. Without it, the battery may be overcharged by the panel, resulting in shortened battery life.

Basically, this device can be set up to simulate a 12V solar panel rated anywhere from 20-120W. It can be used to ensure that the charge controller's MPPT (maximum power point tracking) circuit is operating correctly and features adjustable open-circuit output voltage, adjustable voltage drop with current slope, an adjustable current limit threshold and an adjustable current limit slope to set the short-circuit current.

Maximum power transfer

For a solar panel simulator to be

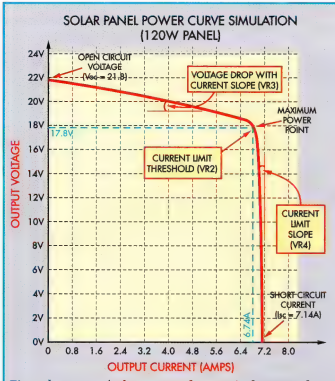


Fig.1: the current/voltage curve for a typical 120W solar panel. VR1 in the simulator is used to set the open circuit voltage while VR2, VR3 and VR4 adjust the other parameters as shown.

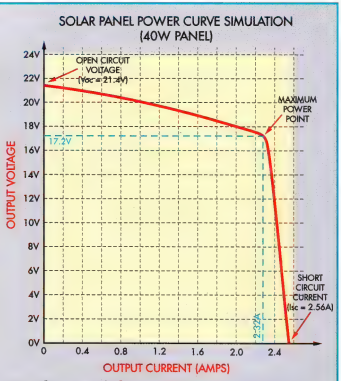


Fig.2: the current/voltage curve for a typical 40W solar panel. The simulator can also be adjusted to match this curve (or the curve for any other panel rated from 20-120W using trimpots VR1-VR4.

of any use, it must duplicate a solar panel's characteristics. This is of particular importance when testing MPPT (maximum power point tracking) devices. MPPT charge controllers are designed to control power delivery to the battery so that the solar panel is always delivering the maximum possible power.

To explain, standard charge controllers (ie, those without MPPT) incorporate a relay or solid-state switch to directly connect the solar panel to the battery. However, this does not fully utilise the power available from the solar panel when charging.

To illustrate this, take a look at Fig.1 which shows the voltage/current curve for a typical 120W solar panel. As can be seen, its output follows a curve that ranges from maximum voltage when the output is open circuit (Voc) to maximum current when the output is shorted (Isc). For a 120W panel, Voc is typically 21.8V, while Isc is typically 7.14A. The maximum power delivered by the panel occurs at 17.8V for a current of 6.74A (ie, 120W).

However, a charge controller that connects the solar panel directly to the battery will deliver 7.1A at 12V, 7.05A at 13V and about 7A at 14.4V, equivalent to 85.2W, 91.7W and 101W respectively. As a result, utilisation of the available power from the solar panel is only 84% or less, depending on the battery voltage. The charge controller subsequently disconnects the solar panel when the battery is charged to prevent overcharging.

By contrast, when an MPPT charge controller is used, the solar cell is loaded so that it delivers 6.74A at 17.8V, to obtain the full power from the solar panel (120W). An efficient switchmode converter reduces this voltage so that it is suitable for charging the battery. If the battery voltage is 13V, then the charging current would be close to 9.3A, assuming a very efficient converter.

Note that this 9.3A charging current is significantly higher than the panel delivers at 17.8V (the maximum power point) and is also higher than the 7.05A that the panel could deliver if connected directly to the battery.

The SILICON CHIP Solar Panel Simulator duplicates the power curve of the solar panel. This allows you to check that the MPPT feature in the Solar Charge Controller is in fact drawing maximum power from the panel.

Main Features

- Simulates 12V solar panels, 20W to 120W
- Can be run from a 24V battery or supply
- Adjustable open circuit voltage (Voc)
- Adjustable voltage drop with current
- Adjustable current limit threshold
- Adjustable current limit slope sets short circuit current
- Additional over-current protection

A simple alternative

In order to duplicate a solar panel power curve, the Solar Panel Simulator must allow adjustment of several of the curve's parameters. These are the open circuit voltage (Voc), short circuit current (Isc), voltage drop with current, current limit threshold and the current limit slope.

A simple solar panel simulator could be made using a variable volt-

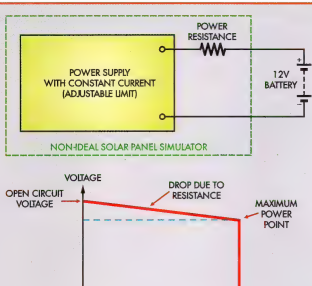


Fig.3: the basics for a simple solar panel simulator. All that is required is a power supply with adjustable voltage and current limit (constant, not foldback) and a power resistor. However, as shown, such a simulator does not emulate the current/voltage curve of a solar panel very accurately.

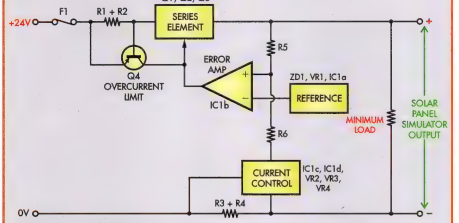


Fig.4: the block diagram for the Solar Panel Simulator circuit. The output voltage is controlled by up to three Mosfets (Q1-Q3) which are driven by error amplifier IC1b. The current control block provides feedback to the error amplifier and the reference block allows the open circuit output voltage to be adjusted. Q4 provides short circuit protection.

age power supply with an adjustable current limit, in combination with a suitable series resistance. Fig.3 shows the details. In this case, the current limiting must be constant. Foldback current limiting can not be used, as this reduces the current as the output voltage drops.

In operation, the power supply would be set for the solar panel's Voc (open circuit voltage) and the current limit would be set for the appropriate Isc (short circuit current). The series resistance in the positive supply provides the necessary voltage drop. In practice, this resistor is chosen to drop the voltage to the maximum power point voltage for the panel at the maximum power point current.

If the maximum power point voltage is Vmp, then the series resistance would be calculated as (Voc – Vmp)/Isc. For a 120W panel, the result is (21.8V - 17.8V)/7.14A = 0.56Ω. The power dissipation in this resistor at full power would be $7.14A^2$ x 0.56Ω = 28.56W (ie, I^2R).

Of course, if the output is shorted, this resistor needs to be able to dissipate power from the 21.8V power supply source at 7.14A, which is 156W. Normally, the output would not be shorted but if connected directly to a battery under charge, the output could be as low as 12V. In this case, the dissipation would be (21.8V – 12V) x 7.14A = 70W.

Simulating a 40W panel

The corresponding figures are much lower if simulating a 40W solar panel. A typical 40W panel has a Voc of 21.4V and an Isc of 2.56A, while its maximum power point is at 17.2V and 2.32A. In this case, a 1.64Ω series resistor would be required and this would dissipate 10.75W at full power.

If the output is short circuited, the dissipation in the resistor would be 54.8W. And when directly charging a battery at 12V, the dissipation would be (21.4 - 12) x 2.56A = 24W.

Unfortunately, the simulator depicted in Fig.3 is not ideal because the current slope is not easily adjustable and its maximum power point is not correct. The current limit could be reduced to bring the maximum power point to the correct position but this also reduces the short-circuit current. In addition, making a resistor that will effectively dissipate the power required over a long period of time is not an easy task.

A better simulator

Instead of using a resistor, a better approach is to use a regulated linear supply designed with deliberately poor regulation. That's because to simulate a solar panel, the voltage must drop under load – normally an undesirable characteristic for such a supply. The simulator is then completed by adding current limiting with an adjustable slope.

Fig.4 shows the block diagram of the Solar Panel Simulator. Its input voltage is 24V so it can run from a 24V battery if necessary. The series element provides a voltage drop and is controlled to maintain the correct output voltage by error amplifier IC1b.

This op amp compares the output voltage to a reference voltage and controls the series element.

When no current is drawn from the output, no voltage appears across resistors R3 and R4 and the current control output is at 0V. At the same time, resistors R5 and R6 divide the output voltage and drive the non-inverting input of the error amplifier (IC1b). As a result, the output voltage from the simulator is maintained so that the voltage on IC1b's non-inverting input equals the reference voltage.

When the simulator's output supplies current, a voltage drop appears across R3 and R4. The current control block senses this and, in response, increases the voltage at the lower end of R6. As a result, the voltage at the non-inverting input of IC1b increases and so IC1b adjusts the series element resistance to reduce the output voltage (ie, to bring the non-inverting input voltage back to the reference voltage). As a result, the output voltage drops as the load current increases.

This same current control block also has a second section which monitors the current through R3 and R4 but this only has an effect at higher current levels. This is configured to reduce the output voltage more dramatically and provides the steep reduction in voltage that occurs at currents above the maximum power point.

Fuse F1 and the over-current limit circuit (based on transistor Q4) protect against excessive current flow should the output become shorted. If there is more than 0.7V across resistors R1 and R2, transistor Q4 conducts, in turn reducing the drive to the series element and thus preventing a higher current flow.

Circuit details

Refer now to Fig.5 for the full circuit details of the Solar Panel Simulator. Note that there are two different ground symbols used, one for the input power supply ground and one for the output ground.

In order to simulate a 120W solar panel, three P-channel Mosfets (Q1-Q3) are connected in parallel as the series control element. These Mosfets share the power dissipation, which can total more than 171W, ie, Vin x Isc where Vin is the input voltage (24V) and Isc (for a 120W panel) is 7.14A.

A single IRF9540 Mosfet can dissipate 140W at a case temperature of 25°C but must be derated at 0.91W/°C above 25°C. Under normal conditions, when providing the maximum power from the Solar Panel Simulator, the total dissipation in the Mosfets is (24V - 17.8V) x 6.74A = 42W, which is shared evenly.

Note that either one or two of these power Mosfets can be omitted to simulate smaller panels.

A quad op amp (IC1a-IC1d) controls the Mosfets. This device is powered from the 24V supply rail via diode D1 and a 100Ω resistor (on pin 4). Zener diode ZD5 (30V) protects the IC from over-voltage transients, while a 10µF capacitor filters the supply. Diode D1 provides reverse polarity protection.

Zener diode ZD4 and its associated 1.2kΩ resistor generates a 9.1V rail. This is then fed to trimpot VR1 and buffered by voltage-follower stage IC1a to provide a variable 0-9.1V reference for IC1b.

IC1b is the error amplifier and it monitors the simulator's output voltage via a 100kΩ resistor to its pin 5 (non-inverting) input. The applied voltage is divided using a 47kΩ resistor which is connected to IC1d's pin 14 output. IC1d's output is at 0V when there is no current flowing through the Mosfets.

IC1b's pin 7 output drives the gates of the paralleled power Mosfets via separate 2.2kΩ resistors. These resistors isolate the gate capacitances from the op amp's output to avoid oscillation. Zener diodes ZD1-ZD3 (18V) protect the Mosfets from excessive gate-source voltages.

IC1b ensures a constant set output voltage from the simulator. For example, if VR1 is set so that the output voltage is 21.8V, the voltage at pin 5 (with no current flow in the output) will be 21.8V x 47kΩ/(47kΩ + 100kΩ) = 6.97V.

As a result, IC1b controls its output so that its pin 6 inverting input is also 6.79V. It functions as an "error amplifier" because it amplifiers the error, or difference, between the target voltage (as set by VR1, via IC1a) and the actual output voltage (after division). Its gain is set to 100 by the 100kΩ and 1kΩ feedback resistors.

Because its gain is so high, when IC1b's pins 5 & 6 are at 6.97V, the output of IC1a is close to 6.97V (actually, about 7.11V). IC1b's output will be about 3V below the input supply voltage. This is just low enough to

Parts List

1 PC board, code 04103111, 99 x 76mm
1 diecast aluminium box, 119 x 94 x 57mm
2 IP65 cable glands for 4-8mm diameter cable
1 heatsink (see Table 1)
2 2-way PC mount screw terminals with 5.08mm pin spacing
2 M205 PC mount fuse clips
1 M205 fuse (F1) (see Table 1)
3 TO-220 Insulating bushes and Silicone insulating washers
4 15mm M3 tapped Nylon spacers
4 M3 x 12mm countersunk Nylon screws
4 M3 x 6mm machine screws
3 M3 x 10mm machine screws
3 M3 nuts
1 100mm length of 0.7mm enamelled copper wire
1 4m length of 0.315mm Nichrome resistance wire
2 10kΩ horizontal mount trimpot (VR1, VR3)
1 100kΩ horizontal mount trimpot (VR2)
1 2kΩ horizontal mount trimpot (VR4)

Semiconductors

1 LM324 quad op amp (IC1)
3 IRF9540 P-channel 100V 23A Mosfets (Q1-Q3) (see Table 1)
1 BC557 PNP transistor (Q4)
1 1N4004 1A diode (D1)
1 1N4148 switching diode (D2)
3 18V 1W zener diodes (ZD1-ZD3) (see Table 1)
1 9.1V 1W zener diode (ZD4)
1 30V 1W zener diode (ZD5)

Capacitors

1 10µF 35V PC electrolytic
3 10nF MKT polyester (code 10n or 103)

Resistors (0.25W, 1%)

3 100kΩ
1 47kΩ
4 10kΩ
3 2.2kΩ (see text & Fig.5)
1 1.2kΩ
2 1kΩ
2 100Ω
3 10Ω (see text & Fig.5)
Selected 5W resistors (see Table 1)

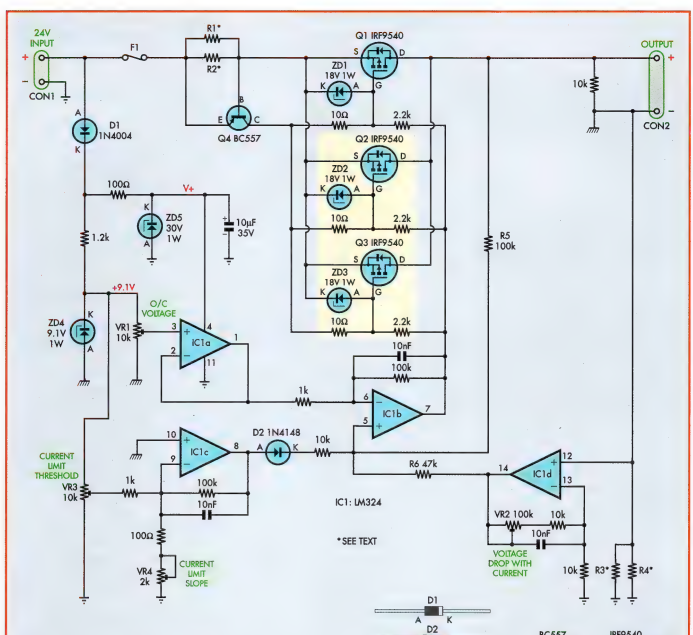


Fig.5: the complete circuit for the solar panel simulator. IC1b forms an error amplifier which controls Mosfets Q1-Q3 to set the output voltage. IC1d monitors the current through the output using resistors R3 & R4 and, together with IC1c, controls IC1b so that the output voltage behaves like a solar panel. The Mosfets and zener diodes highlighted in yellow (and their associated 10Ω and 2.2kΩ resistors) are necessary to simulate higher-power panels – see Table 1.

turn the Mosfets on and so a small amount of current flows through the 10kΩ resistor across the output.

This system provides negative feedback, so that the correct output voltage (as set by VR1) is maintained, even though the characteristics of the Mosfets can vary with temperature and other factors. If the output voltage drops, IC1b's output goes lower and increases the drive to Mosfets Q1-Q3 to maintain the target output voltage. So this part of the circuit behaves like a linear regulator.

Resistors R3 and R4, in combination with amplifier IC1d, monitor the current through the load. This feeds back into the output voltage since IC1d's output is connected to the lower end of the voltage divider made up of R5 & R6. The higher the output current, the greater the voltage across R3 & R4 and thus the greater the voltage at the pin 14 output of op amp IC1d.

This in turn increases the voltage at the non-inverting input of error amplifier IC1b. As a result, the error amplifier's output increases and this throttles back the Mosfets to reduce the Solar Panel Simulator's output

voltage. Trimpot VR2 sets the gain for IC1d and thus controls the rate at which the output voltage drops with increasing current.

Op amp IC1c sets the current limit and also controls the rate at which the output voltage drops off when it is reached. At low currents, IC1c's output is lower than the voltage at the junction of resistors R3 & R4 and so diode D2 is reverse biased. As a result, it does not affect the error amplifier's input voltage.

IC1c is configured with a much higher gain than IC1d (about 100). The current limit threshold, as set by trimpot VR3, holds the output of IC1c low until a preset current is reached. Above that point, IC1c takes over from IC1d due to its high gain.

Basically, VR3's setting determines the current at which the output voltage begins to steeply decline. When the set level is exceeded, IC1c controls the error amplifier via diode D2 and a 10kΩ resistor, dramatically reducing the simulator's output voltage due to its high gain. The actual rate of voltage drop with current is set by adjusting IC1c's gain using VR4.

Construction

The circuit is easy to build, with all parts mounted on a PC board coded 04103111 and measuring 99 x 76mm. This board is mounted on 15mm tapped spacers inside a diecast aluminium box measuring 119 x 94 x 57mm. Note, however, that additional heatsinking for the Mosfets is necessary – see photos & Table 1.

Note also that, depending on the solar panel being simulated, some parts may not be required. Table 1 summarises the parts needed to simulate various solar panels and their corresponding heatsink requirements.

Before mounting any parts, check the PC board for broken tracks and for shorts between tracks and pads. Check also that the hole sizes are correct for each component to fit neatly. The screw terminal holes are 1.25mm in diameter compared to the 0.9mm holes for the ICs, resistors and diodes. Larger holes again are required for the fuse clips – test fit these clips to ensure that the holes are correct.

Begin the assembly by installing the wire links, then install the resistors. Table 2 shows the resistor colour codes but you should also check each one using a DMM before it is installed. The values for resistors R1-R4 must be selected according to the panel to be simulated – see Table 1. Note that R2 & R4 are not needed to simulate panel current ratings of less than 4A.

Resistors R1 & R2 are chosen so that the current limit is greater than the short circuit current for the solar panel

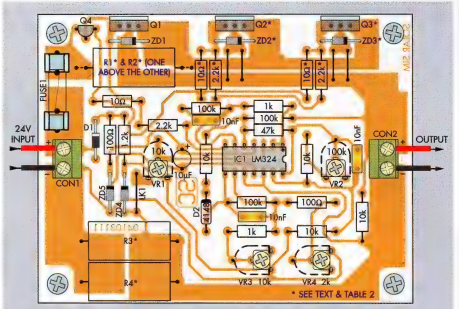


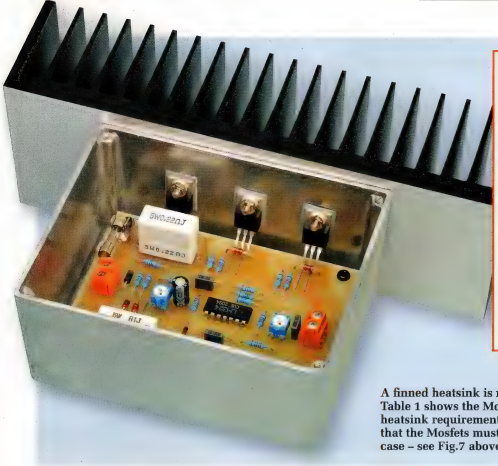
Fig.6: follow this overlay diagram to build the PC board. Mosfets Q1-Q3 are lined up along the edge of the board as they require a large heatsink. Some of the components (R2, R4, Q2-Q3, ZD2-ZD3 and some 10Ω and 2.2kΩ resistors) are only required for simulating larger solar panels – see Table 1 below.

Table 1: Mosfets & Current Sensing Resistors

Solar Panel Short Circuit Current & Fuse Rating (F1)	Resistors R1 & R2	Resistors R3 & R4	Mosfets & Zener Diodes Required	Heatsink
<2A	0.47Ω 5W (R1)	0.22Ω 5W (R3)	Q1 & ZD1	2.1°C per watt
2-4A	0.22Ω 5W (R1)	0.1Ω 5W (R3)	Q1& Q2 ZD1 & ZD2	1.4°C per watt
4-8A	0.22Ω 5W (R1) 0.22Ω 5W (R2)	0.1Ω 5W (R3) 0.1Ω 5W (R4)	Q1, Q2 & Q3 ZD1, ZD2 & ZD3	0.7°C per watt

Table 2: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	3	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	4	10kΩ	brown black orange brown	brown black black red brown
❑	3	2.2kΩ	red red red brown	red red black brown brown
❑	1	1.2kΩ	brown red red brown	brown red black brown brown
❑	1	1kΩ	brown black red brown	brown black black brown brown
❑	1	100Ω	brown black brown brown	brown black black black brown
❑	3	10Ω	brown black black brown	brown black black gold brown



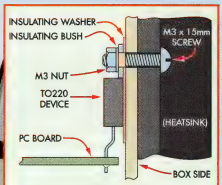


Fig.7: Mosfets Q1-Q3 must be electrically isolated from the case using silicone insulating washers and insulating bushes. After mounting each device, use your DMM (set to a high Ohms range) to check that its metal tab is indeed isolated from the case.

A finned heatsink is necessary to keep the Mosfets cool. Table 1 shows the Mosfets required and the corresponding heatsink requirements for different output currents. Note that the Mosfets must be electrically isolated from the case – see Fig.7 above.

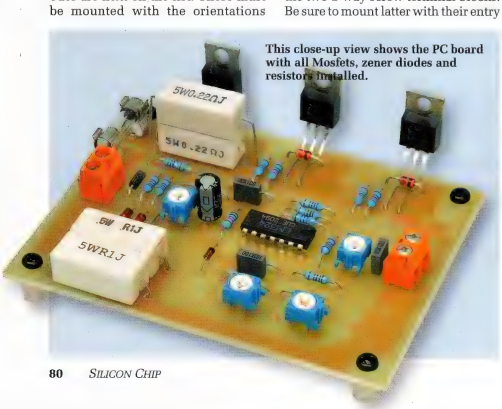
under simulation. If both resistors are used, they should be stacked, one on top of the other – see photo below. Extra mounting holes are included for the second resistor. If both R3 and R4 are used, they are mounted side-by-side on the PC board.

Diodes D1 & D2 and the zener diodes are next on the list. These must be mounted with the orientations shown. Install zener diodes ZD1-ZD3 as required, as indicated in Table 1. ZD4 and ZD5 are required in all cases.

IC1 can now be soldered into place (pin 1 at top right), followed by the capacitors. Make sure that the electrolytic type is orientated correctly. The trimpots can then go in, followed by the two 2-way screw terminal blocks. Be sure to mount latter with their entry holes facing outwards.

Follow these with the fuse clips for F1. Make sure that these are orientated correctly, with the end stop toward the outside of the fuse for each clip. If this is not done, you won't be able to install the fuse later on.

The PC board assembly can now be completed by installing Mosfets Q1-Q3 – see Table 2. Each of these devices is installed with its metal tab facing outwards and with the mounting hole centre in each tab about 21mm above the PC board.



This close-up view shows the PC board with all Mosfets, zener diodes and resistors installed.

Final assembly

The PC board can now be mounted inside its box. Start by placing the board inside the case and marking out the positions of the four mounting holes. These should then be drilled using a 3mm drill. Countersink the holes on the outside of the case, then install the four 15mm x M3 tapped spacers and temporarily secure the board in place.

Next, mark the mounting holes for the Mosfets, then remove the PC board and drill the holes to 3mm. That done, use an oversize drill to remove any metal swarf so that the area around each hole is perfectly smooth. This is necessary to prevent punch-through

of the insulating washers when the devices are secured to the case.

Once the mounting holes have been drilled, you can use the case as a template to mark out the corresponding holes in the selected heatsink (refer Table 1 to select a suitable heatsink). Once that's done, the Mosfets and the heatsink can be fastened to the side of the case as shown in Fig.7.

Note that it's necessary to isolate each device tab from the case using an insulating washer and insulating bush. Once they have been installed, use a DMM (set to Ohms) to confirm that the metal tabs are indeed isolated from the case. If a low-resistance reading is measured, loosen each device in turn until the fault clears and check for puncture marks or holes in the silicone washer for the faulty assembly.

Make sure the Mosfets are securely attached to the heatsink (or side of the box) to ensure that the heat is efficiently transferred.

Finally, you will need to drill holes in either side of the case, near the screw terminal block, to accept the external wiring connections. These can be secured using cable glands.

Setting up

The step-by-step setting-up procedure is as follows:

(1) Set trimpots VR3 & VR4 fully clockwise and install fuse F1.

(2) Apply 24V to CON1 and adjust VR1 for the correct solar panel open circuit voltage at the output (CON2).

(3) Attach a variable resistive load made from Nichrome wire to the simulator's output (see adjacent panel and Table 3 for the details on making this load).

(4) Adjust this resistance to give the maximum power point. This resistance value can be calculated by dividing the maximum power point voltage by the maximum power point current. Table 3 shows some typical values for various panels.

(5) Adjust VR2 for the correct output voltage at the maximum power point.

(6) Adjust VR3 slowly anti-clockwise until the voltage suddenly drops, then back off slightly in the other direction.

(7) Reduce the load resistance (ie, by sliding the clip along the Nichrome wire) until the output voltage falls to 10V (but don't go lower as this greatly increases the dissipation).

(8) Check the voltage/current graph for your panel to determine its output current at that voltage and adjust VR4 to match this current. This gives the correct current slope for the simulator.

For example, for a 120W solar panel, the output current at 10V is typically about 7A – see Fig.1. For a 40W panel, the corresponding figure is about 2.45A. Note that this adjustment is not particularly critical.

To measure this current, simply connect your DMM (set to Amps) in series with the load. Alternatively, you can calculate the required voltage drop across R1 (or R1 & R2) and adjust VR4 to give this voltage.

Once the adjustments have been completed, the Solar Panel Simulator is ready for use. SC

Making An Adjustable Load From Nichrome Wire

An adjustable load is necessary to test and calibrate the simulator and this can be made using Nichrome wire.

Table 3 shows the load resistances required for maximum power from a number of typical solar panels ranging from 40W to 120W. Each resistance is used to load the Solar Panel Simulator at the maximum power point for a given panel size. A lower resistance is then required to check the current limit threshold and the current slope.

Note that it is not necessary (nor desirable) to short circuit the output of the Solar Panel Simulator. The slope of the current limit can be checked against the graph for that panel by loading the simulator with resistances above 0Ω.

Nichrome wire can dissipate about 50W per metre before it becomes red hot. Assuming a diameter of 0.315mm, it has a resistance of about 13.77Ω per metre. As a result, you may need to use several paralleled strands of Nichrome wire to share the current and reduce heating to an acceptable level.

A variable resistance can be made by first connecting the 0V output of the Solar Panel Simulator to one end of the wire. A flying lead with a clip can then be used to connect the positive output to various points along the wire. The wire itself should be wrapped around insulating material such as a length of timber. Alternatively, it can be suspended on a board between two points.

Note that the resistance wire will become hot in use and could scorch any timber that it comes in contact with if left on for long enough. For this reason, keep it clear of any combustible material, do not touch it during operation and do not wrap it around plastic pipe or conduit.

Table 3: Test Load Resistance Required For Setting The Maximum Power Point

Panel Rating	Maximum Power Point	Load Resistance Required For Maximum Power	Nichrome Wire (0.315mm diameter at 13.77Ω/m)
40W	17.2V @ 2.32A	7.41Ω	2 x 1080mm-long parallel strands
65W	17.2V @ 3.78A	4.55Ω	2 x 991mm-long parallel strands
80W	17.6V @ 4.55A	3.87Ω	2 x 843mm-long parallel strands
120W	17.8V @ 6.74A	2.64Ω	2 x 767mm-long parallel strands

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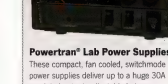

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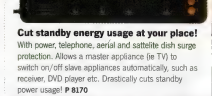

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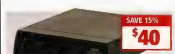

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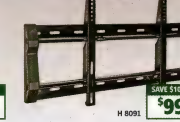

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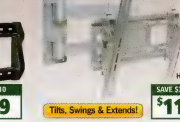

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Great for tackling jobs around the house, on the car, boat or 4WD! Includes a massive array of tools - hammer, pliers, allen keys, ratchet screwdriver, lug crimper & knife. See website for full list.

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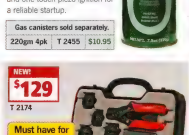

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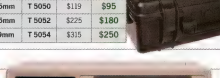

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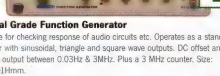

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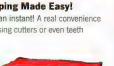

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(SC May '10) This compact stereo amp module puts out 2x20W RMS into 4Ω and is 12V powered (SLA battery or plugpack). Distortion typically <0.03%. Bass & treble controls.

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(SC Oct '04) Connects in-line with any USB connection and boosts power to a full 5V 500mA DC. Requires 9VDC plugpack M 8925A + M 9191 tip $26.55.

NEW KITS!

$14.95ea

Toslink S/PDIF Converter Kits

(SC October '10) Got a coaxial output but only an optical input? Or perhaps the other way around? No problem! These converter kits are the solution - plus they minimise hum on coax connections. Requires 6-15V AC or 9-20V DC plugpack. **K 5174 Toslink to S/PDIF, K 5175 S/PDIF to Toslink**

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(SC June '08) Allows you to send line level signals over long distances with minimal hum and noise. Requires 9-30VDC. Size: 103x85mm.

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USB Mains Sensing Switch Kit. **(SC January '09)** Monitors your PC's USB port and automatically turns all your gear on and off as required. No need to crawl under the desk to disconnect devices!

More Great Kit Designs From Silicon Chip...

K 6120

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(SC May '10) Compact charging module for MP3 players, GPS devices & game consoles. • 89% efficiency • Very low quiescent current will not flatten your battery • 12V input, 5V 525mA output.

Counts up or down from 1s to 100 hours in 1s steps

NEW KIT!

$87.95

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(SC Sept '10) Mini Mic Pre-Amp Kit. Boosts signal levels for better volume from unpowered mics when used with a mixer or PC sound card. • Suits balanced or unbalanced mics • Low noise & distortion • Line level output. • 5-20VDC input.

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Hearing-aid wearers often have difficulty understanding conversations in noisy environments, especially if they have switched their personal hearing aid from microphone mode to T-coil mode. This projects solves that problem.

By JOHN CLARKE

Microphone To Neck Loop Coupler For Hearing Aids

IN ORDER TO LISTEN to a hearing loop via a hearing aid fitted with a T-coil, the wearer needs to switch off the inbuilt microphone receiver. Instead, the hearing aid is switched to T-coil mode so that it can receive and process signals from the hearing loop. Such loops are often installed in public buildings, churches and halls.

However, while this allows signals from the hearing loop to be heard, it prevents the user from hearing ambient sounds. It also prevents them from hearing other people around them, making conversation difficult.

This Microphone to Neck Loop Coupler is the answer to this problem. It comes in two parts: (1) a small battery-powered unit that can be slipped into a shirt pocket; and (2) a wire neck loop coil that the user wears around . . . well, yes . . . their neck. This neck loop plugs into the battery-powered unit via a 3.5mm mono jack socket.

The battery-powered unit has an inbuilt electret microphone, a microphone preamplifier and an amplifier to drive the neck loop. In use, the microphone picks up local sounds (or conversations) and sends them to a neck loop. The neck loop then couples the signal into the hearing aid via its T-coil.

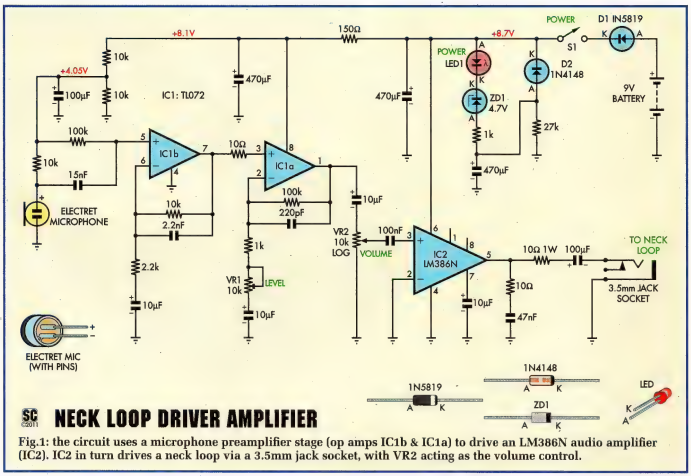
A volume control allows the level to be adjusted to suit the listener's requirements, or it can be turned right down (or the unit switched off) to eliminate ambient sound.

In summary, this unit can be thought of as a personal version of the much larger inductive loop systems installed in public places. It can operate in parallel with such systems or on its own.

Presentation

As shown in the photos, the preamp/coil-driver unit is housed in a small hand-held case. A power switch, power indication LED, volume control and 3.5mm jack socket are located on an end panel, at the top of the unit.

Power comes from a 9V battery and the current consumption is around 10mA. This should give up to 40



SC 2011 NECK LOOP DRIVER AMPLIFIER

Fig.1: the circuit uses a microphone preamplifier stage (op amps IC1b & IC1a) to drive an LM386N audio amplifier (IC2). IC2 in turn drives a neck loop via a 3.5mm jack socket, with VR2 acting as the volume control.

hours of use before the battery needs changing. The power LED also functions as a rough battery-level indicator. Its initial brightness when power is applied is dependent on battery voltage. Once power has been applied, the LED brightness is automatically reduced to conserve the battery (more on this later).

Circuit details

Take a look now at Fig.1 for the circuit details. It uses a TL072 dual op amp, an LM386 audio amplifier IC, an electret microphone and a few sundry bits and pieces.

Signals picked up by the microphone are fed to the non-inverting input of IC1b via a 15nF capacitor. IC1b is the microphone preamplifier and is wired as a non-inverting stage with a gain of about 5.5 as set by the 10kΩ and 2.2kΩ feedback resistors.

The 15nF capacitor and 100kΩ load resistor at the pin 5 input set the low frequency roll-off to about 100Hz. As shown, the 100kΩ resistor connects to a supply that's nominally at 4.05V, as set by two 10kΩ divider resistors across the 8.1V supply rail. This is bypassed using a 100µF capacitor. The supply for the electret microphone is via another 10kΩ resistor from this 4.05V source.

The low frequency roll-off for IC1b is 7.2Hz, as set by the 2.2kΩ resistor at pin 6 and the 10µF capacitor to ground, while the high-frequency roll-off starts at around 7.2kHz.

IC1b's output appears at pin 7 and is fed to the pin 3 (non-inverting) input of IC1a via a 10Ω stopper resistor. IC1a is also wired as a non-inverting amplifier and its gain is adjustable via 10kΩ trimpot VR1. In its minimum position, the gain is 101 as set by the 100kΩ and 1kΩ resistors, while its low-frequency roll-off is 16Hz due to the 1kΩ resistor and 10µF capacitor.

At the other extreme, when VR1 is set to 10kΩ, the gain is about 10 and the low-frequency roll-off is at 1.45Hz.

The high-frequency roll-off for this stage is set by the 220pF capacitor across the 100kΩ feedback resistor. This rolls off frequencies above about 7.2kHz.

Following IC1a, the signal is AC-coupled via a 10µF capacitor to a 10kΩ volume control pot (VR1). This sets the signal level applied to audio power amplifier stage IC2 (LM386). IC2 can provide up to about 14mA RMS into a 43Ω load. This load consists of a 10Ω resistor at the output (pin 5) plus the neck loop itself, the latter consisting of a 150mm-diameter 4-turn wire loop in series with a 33Ω resistor.

IC2 has a gain of 20 and is powered from an 8.7V supply rail which is applied to pin 6. This is bypassed with a 470µF capacitor. A separate 10µF supply bypass capacitor at pin 7 removes supply ripple from the amplifier's input stages.

At the output, a Zobel network comprising a 10Ω resistor and 47nF capacitor prevents amplifier instability. The output appears at pin 5 and drives the neck loop via the aforementioned 10Ω 1W resistor and a series 100µF capacitor. This capacitor provides low-frequency roll-off for signals below 37Hz (assuming a 43Ω load), as well as removing DC from the signal.

Power supply

Power for the circuit is derived from a 9V battery, with diode D1 providing protection against a reverse polarity

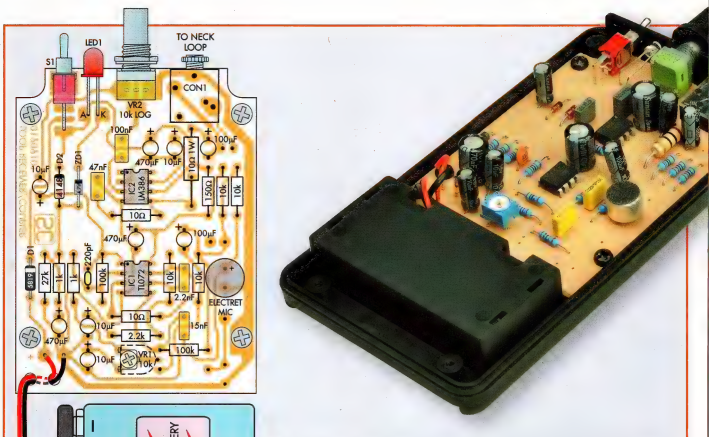


Fig.2: follow this parts layout diagram and the above photo to build the unit. The assembly is straightforward but take care not to get the ICs mixed up and make sure that all polarised parts are correctly orientated. Power comes from a 9V battery.

connection. D1 is a Schottky type, so the voltage drop across it is only about 0.3V. Switch S1 provides power on/off switching.

LED1 is used to indicate both power status and battery condition. It works like this: when power is first applied, current for the LED flows through 4.7V zener diode ZD1, the 1kΩ resistor and the 470µF capacitor (which is initially discharged). If the 9V battery is fresh, it provides 8.7V at the anode of LED1 (due to the drop across D1).

Further voltage drops of 1.8V and 4.7V take place across LED1 and ZD1 respectively, leaving 2.2V across the 1kΩ resistor. As a result, 2.2mA flows through LED1 and the LED lights.

At lower battery voltages, there is less voltage across the 1kΩ resistor, so less current flows and the LED is dimmer. For example, at a battery voltage of 7V, there is only about 0.2V across the 1kΩ resistor and so the current is reduced to just 0.2mA and the LED barely lights.

Regardless of the battery voltage, when the LED lights the 470µF capacitor quickly charges. As a result, the LED current is progressively reduced and the LED automatically dims to conserve battery power. The 27kΩ resistor across the 470µF capacitor ensures that the LED stays lit but at reduced brightness, to indicate that the power is on.

Basically, the 470µF capacitor is included only to provide battery voltage indication at power up. When the power is subsequently switched off, diode D2 discharges the 470µF capacitor. This ensures that the battery condition indicator circuit is ready the next time power is applied.

Power amplifier IC2 is powered directly from the 8.7V rail, while IC1 is powered from this rail via a 150Ω resistor, giving a rail of about 8.1V. A 470µF capacitor on pin 8 of IC1 filters this 8.1V rail and prevents instability.

Construction

The Microphone To Neck Loop Coupler is constructed on a PC board coded 01209101 and measuring 65 x 86mm. This is housed in a remote control case measuring 135 x 70 x 24mm. Separate labels attach to the top end panel of the case and to the front.

Note that the same PC board was used for the Hearing Loop Receiver described in the September 2010 issue (the two circuits are almost the same). As a result, there are a few unused component holes in the PC board for the Microphone To Neck Loop Coupler project (the unused component positions are for extra parts used in the Hearing Aid Loop Receiver).

The PC board is designed to mount onto integral mounting bushes in the base. Before installing any of the parts, check that the top edge of the PC board is correctly shaped at the corners, so that it fits into the case. If not, it can be filed to shape using the PC board overlay outline as a guide.

Begin construction by checking the PC board for any defects and repair these if necessary. Check also that the PC board mounting holes are correct;

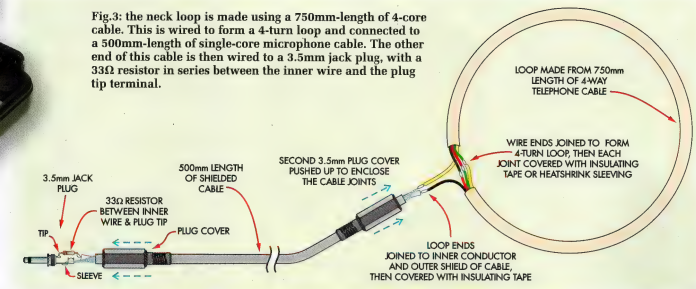


Fig.3: the neck loop is made using a 750mm-length of 4-core cable. This is wired to form a 4-turn loop and connected to a 500mm-length of single-core microphone cable. The other end of this cable is then wired to a 3.5mm jack plug, with a 33Ω resistor in series between the inner wire and the plug tip terminal.

they should be 3mm in diameter, as should the holes for the battery leads

Fig.2 shows the parts layout on the PC board. Start the assembly by installing the resistors. Table 1 shows the resistor colour codes but you should also use a DMM to confirm each value as it is installed. Once these are in, install the diodes, taking care to orientate them as shown.

Next, install the two PC stakes at the bottom lefthand corner (for the battery leads), then install the two ICs. Be careful not to get the ICs mixed up and be sure to install them the right way around. The ICs can either be soldered directly to the PC board or mounted via sockets.

The capacitors are next on the list. Take care with the polarity of the electrolytics and make sure that no capacitors are higher than 12.5mm, otherwise the lid of the case will not fit correctly.

Trimpot VR1, switch S1, potentiometer VR2 and the 3.5mm mono socket can now all be installed. That done, install LED1. This mounts horizontally, with its leads 6mm above the PC board and its anode lead to the left.

To do this, first bend its leads down by 90° about 12mm from its body (make sure it is orientated correctly). That done, cut a 6mm-wide cardboard spacer, then push the LED's leads down onto this before soldering them.

The board assembly can now be completed by installing the electret microphone. Make sure it is correctly orientated – its positive side goes towards the top and its face must be no higher than 12mm above the PC board.

Fitting the battery connector

The battery connector is installed by first passing its leads through the battery compartment of the case, and then looping them through the holes in the PC board – see Fig.2. This anchors the leads which can now be soldered to the PC stakes (watch the polarity).

Once that's done, attach the label to the top end panel of the case and drill out the holes for the power switch, indicator LED, the pot and the 3.5mm socket. The PC board can then be secured to the base of the case using four M3 x 5mm screws into the integral mounting bushes.

The case lid also requires a small cut-out to clear the pot shaft plus a small hole for the microphone. This latter hole is drilled by first fitting the label to the lid, then drilling a 3mm hole in the position indicated, so that it is centred over the microphone. A

Table 2: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
100nF	0.1µF	100n	104
47nF	.047µF	47n	473
15nF	.015µF	15n	153
2.2nF	.0022µF	2n2	222
220pF	NA	220p	221

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	2	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	27kΩ	red violet orange brown	red violet black red brown
❑	4	10kΩ	brown black orange brown	brown black black red brown
❑	1	2.2kΩ	red red red brown	red red black brown brown
❑	2	1kΩ	brown black red brown	brown black black brown brown
❑	1	150Ω	brown green brown brown	brown green black black brown
❑	1	33Ω*	orange orange black brown	orange orange black gold brown
❑	2	10Ω	brown black black brown	brown black black gold brown

* attached to jack plug – see Fig.3

Here's another view of the fully-assembled unit. Note that you will have to make cut-outs in the end panel and in the case lid to clear the pot shaft.

The completed unit is lightweight and can be easily clipped onto clothing or slipped into a pocket. The loop is worn around the neck and couples signals into the hearing-aid's T-coil.

The top panel of the unit provides access to the 3.5mm jack socket, the volume control and the power switch. Also present is the power indicator LED.

How To Make Your Own Labels

If you are building this project from a kit, then the labels will probably be supplied. If not, the labels can be downloaded as PDF files from the SILICON CHIP website and printed out onto photo paper with a peel-away adhesive backing or onto clear plastic film.

If you are using clear plastic film (eg, overhead projector film), you can print the label as a mirror image so that the ink is at the back of the film when it is placed onto the panel.

Wait until the ink is dry before cutting the label to size. The film can then be affixed in place using an even smear of neutral-cure silicone. If you are affixing the label to a black panel (eg, if using the specified case), use coloured silicone such as grey or white so that the lettering will stand out.

The holes in labels can be cut out using a sharp hobby knife after the silicone has cured.

3mm LED bezel can then then fitted to this hole, to provide a neat appearance.

Making the neck loop

The neck loop is made using a 750mm-length of 4-core telephone cable. Alternatively, you can use RJ11 4P4C extension cable if you want black (telephone cable is usually white).

Fig.3 shows how the cable is wired to form a 4-turn loop. This is then connected to a 500mm-length of white or black single-core microphone cable. A 3.5mm jack plug and a 33Ω resistor are then fitted to the other end of this cable, so that it can be plugged into the microphone pick-up/amplifier unit.

Testing

To test the unit, apply power and check that the power LED lights. If it does, check that there is about 8.1V between pins 4 & 8 of IC1 (assuming a 9V battery supply). Similarly, IC2 should have about 8.7V between pins 4 & 6.

If this all checks out, plug the neck loop into the socket and check the performance of the unit. To do this, you will need either a hearing aid with a T-coil or a hearing loop receiver such as the one described in the September

Parts List

1 plastic case, 135 x 70 x 24mm (Jaycar HB5610 or equivalent – see text)
1 PC board, code 01209101, 65 x 86mm (or use 01209102 to suit Altronics H0342 case)
1 end panel label, 55 x 14mm
1 front panel label, 67 x 49mm
1 miniature PC-mount SPDT toggle switch (S1)
1 3.5mm PC-mount stereo socket
1 3.5mm stereo line plug
1 3.5mm line plug for neck loop 'Y' covering
1 10kΩ horizontal trimpot (VR1)
1 10kΩ log potentiometer, PC-mount, 9mm square (VR2)
1 knob to suit potentiometer
2 DIP8 IC sockets (optional)
1 10mm OD PC-mount electret microphone
1 3mm LED bezel
1 9V (216) alkaline battery
1 750mm length of 4-way white or black sheathed flat modular telephone wire
1 500mm length of white or black sheathed single-core shielded cable
1 9V battery clip
2 PC stakes
4 M3 x 5mm screws

Semiconductors

1 TL072 dual op amp (IC1)
1 LM386 1W amplifier (IC2)
1 4.7V 1W zener diode (ZD1)
1 1N5819 1A Schottky diode (D1)
1 1N4148 switching diode (D2)
1 3mm red LED (LED1)

Capacitors

3 470µF 16V PC electrolytic
2 100µF 16V PC electrolytic
4 10µF 16V PC electrolytic
1 100nF MKT polyester
1 47nF MKT polyester
1 15nF MKT polyester
1 2.2nF MKT polyester
2 220pF ceramic

Resistors (0.25W, 1%)

2 100kΩ	1 150Ω
1 27kΩ	1 33Ω
4 10kΩ	2 10Ω
1 2.2kΩ	1 10Ω 1W
2 1kΩ	

Miscellaneous

Heatshrink tubing

2010 issue of SILICON CHIP. Note that this receiver needs to be at right angles to the loop. So for a horizontally mounted loop, the receiver is held in the vertical plane.

Trimpot VR1 is simply adjusted for best results, so that the volume control (VR2) works over its range without excessive levels at full volume.

Another method of checking the unit is to plug headphones into the outlet socket and check that the microphone sound is amplified.

Loop orientation

In operation, the neck loop signal is magnetically coupled to the T-coil. However, because the loop is worn around the neck, it is not orientated in the optimum position for the hearing aid to receive the field. In addition, the T-coil is not exactly perpendicular to the neck loop and so the signal level is not as high as it would otherwise be.

This has been taken care of in the design of the Microphone To Neck Loop Coupler circuit. Basically, it has enough gain to drive the loop so that a satisfactory level is obtained in the hearing aid.

However, if the neck loop is plugged into an MP3 player or similar, the signal may not be sufficient for satisfactory sound levels to be heard. In some cases, it may be simply a matter of adjusting the volume on the MP3 player but that's by no means guaranteed.

Note that if you do intend plugging the neck loop into a stereo outlet (eg, an MP3 player), you will need to install an additional 33Ω resistor in the jack plug. This extra resistor goes between the loop and the ring connection of the jack plug and is necessary to provide stereo-to-mono mixing of the signal.

Belt clip

Finally, if you require a belt clip for the unit, take a look at the Altronics H0349. It's on their website at **www.altronics.com.au** We have also produced a slightly modified PC board pattern (01209102) to suit the Altronics H0342 hand-held case. SC

RMS PARTS

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AS FEATURED IN SILICON CHIP LED DAZZLER (P24, FEBRUARY 2011)

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No Electronics Needed
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Power LEDs mounted on 20mm Star PCB. Various Colours available.
Pure White W42182 $3.90+GST
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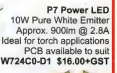
Warm White N42182 $3.90+GST



P3-II Star 2W LEDs
Power LEDs mounted on 20mm Star PCB. Various Colours available.
Pure White WS2182 $2.95+GST
Warm White NS2182 $2.95+GST

P5-II RGB Power LED
High power RGB LED mounted On 20mm Star PCB
Drive each colour @ 350mA
Ideal for wall wash applications
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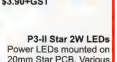

SMD RGB LED
General purpose RGB LED in PLCC-6 package
Drive each colour @ 20mA
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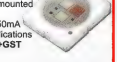
Top View SMD White LED
High Brightness pure white LED in small PLCC package
Great for strip lighting
Typical luminous intensity 1600mcd
KWT803-S $0.30ea+GST



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The Atten ADS1102CA Digital Storage Oscilloscope

"Hands-On" Review by Mauro Grassi.

This affordable dual-channel DSO has many features found in more expensive oscilloscopes, with a wide analog bandwidth of 100MHz, a colour LCD screen and good connection options. It is light, portable and very quiet in operation.

The prices of entry-level DSOs have fallen in recent years and many have features previously found only in more expensive models.

One of the most affordable in its class is the Atten ADS1102CA, a dual channel model with an analog bandwidth of 100MHz and a colour TFT LCD screen.

While the higher bandwidth of this DSO makes it substantially more expensive than, say, 20-25MHz or even 50-60MHz models, it still represents very good value for the combination of software and hardware features that it has.

LCD screen

The screen is a 64K colour (16-bit), 5.7 inch TFT LCD with a resolution of 320 x 234 pixels (close enough to QVGA at 320 x 240 pixels). You can vary the brightness of the LCD and its intensity, as well as choosing the look of the grid. The rendering can be in vector or "dot" mode and you can enable timed or infinite persistence. While the screen is big, its resolution is relatively low – the major compromise with this model.

A colour screen is considerably more attractive than a monochrome display though and in most cases, the resolution of the screen won't matter particularly, because you'll be looking for qualitative features of the waveform (and any quantitative features can be measured).

On the plus side, the display is bright and can be read well over a range of viewing angles.

Front panel layout

The front panel of the ADS1102CA mimics other DSOs we have reviewed. The layout of the controls is logical, with buttons grouped according to function.

There are dedicated offset and amplitude (vertical scale) knobs for each of the two analog channels, and another pair for the horizontal timebase. The timebase can be varied between 2.5ns and 50s per division. The real time sampling rate of the ADS1102CA is 1GS/s but this only applies if using one channel. If using two channels, you need to halve this rate (and the rate of 500MS/s applies only if the timebase is faster than 50ns per division).

Each knob is "digital" and responds to turning and pressing. There are two other, smaller, knobs on the front panel. One is used to set the trigger level and is grouped with the buttons associated with the triggering menus. The other is a so-called "universal" knob, used to change different settings depending on the context and it lights up when it can be used to change a setting.

The six menu buttons are laid out in two groups of three; there is a dedicated help button and illuminated buttons for each channel.

In addition, five context-sensitive buttons run down the right hand side of the display that correspond to the menus displayed on the screen. The menu system is simple to use and appears and disappears as required. It is hiearchical and in some cases encompasses more than one on screen page. You move from one "page" to the next using the lowest of the five buttons.

The menu display disappears when a timeout period expires without

Specifications At A Glance:

Input channels:	2
Analog Bandwidth:	DC to 100MHz
Sampling Rate:	1GS/s (single channel)
Memory Depth:	40Kpts
Vertical Sensitivity:	2mV/div (at x1)
Vertical Resolution:	8 bits
LCD Display:	5.7inch 16-bit colour TFT QVGA, 320 x 234 pixels
Size and Weight:	305 x 154 x 133mm; 2.3kg

user input and this can be set from two to 20 seconds (the timeout can also be disabled). There is a dedicated button, just above the five context sensitive buttons, that can be used to make the menus disappear instantly.

When the menus are visible, you can still see 10 of the 12 timebase divisions of the waveform display (and always eight vertical divisions).

As mentioned, some of the pushbuttons are illuminated, usually green but some change colour; the RUN/STOP button is green when running and red when stopped. Each of the two channels has an illuminated button that is lit green when the channel is enabled. Pressing this button also brings up the options for that channel.

Analog input connectors

There are BNC connectors for each of the two analog channels that accept (passive) probes, as well as an external trigger input. The ADS1102CA is supplied with two passive 100MHz probes with switchable x1 or x10 attenuation, although the settings allow for x10 and x1000 probes as well.

The ADS1102CA has a 1kHz compensation output, for calibrating the probes. You connect the probe to the compensation output and adjust its trimmer capacitor until the "square" wave looks square (see Fig.1). Apart from the two BNC sockets for the two

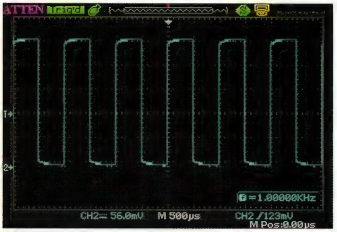

Fig.1: this screen grab shows the 1kHz square wave used for probe compensation. The frequency counter is in use showing the frequency is very close to 1kHz. The voltage scale is shown as 56mV per division (on the "fine" setting) which makes the amplitude around 170mV (or 340mV peak-to-peak). Note that the ADS1102CA can also perform a self test and self calibration procedure.

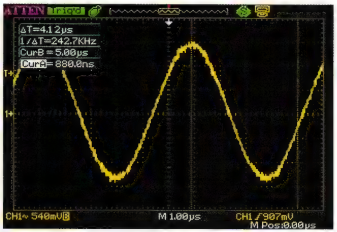

Fig.2: this shows the cursors being applied to a simple sinusoid. The cursors are in the time domain (horizontal axis) and you can position them anywhere on the screen using the "universal" knob. In this case we can accurately read the time difference between the two cursors as 4.12µs. The cursor time positions are also shown.

analog channels, there is a third BNC socket for an external trigger input.

Signal-coupling

Pressing the channel button allows you to vary the coupling for that channel (AC, DC or GND), as well as to apply bandwidth limiting. The GND coupling simply connects the channel to a GND reference. This oscilloscope's inputs have a fixed 1MΩ impedance and are rated for 400V (CAT II). There is no 50Ω input option.

Bandwidth limiting

Each of the two analog channels can be bandwidth-limited to 20MHz. This is a good idea when you want to ignore very high frequencies as it reduces noise (ie, above the 20MHz cutoff frequency). If you know beforehand that your signals are below 20MHz, you should enable this.

Note that although this is a 100MHz oscilloscope, this requires the probe to be used in its x10 setting. The bandwidth is only 10MHz if you use the probe in the x1 setting and so the inputs are essentially always bandwidth-limited in this case.

In the menus for each channel you can also choose whether the vertical knob for each channel works in "fine" or "coarse" mode; in the latter, the knob follows the common 1-2-5 sequence while in fine mode, there are many more intermediate steps. Pressing the vertical scale button toggles between the two modes. The "fine" mode is good for using the available screen area most effectively.

The offset knob, when pressed, sets the GND reference for the channel at 0V (centred vertically on the display). From there you can move it up or down as necessary to position the trace on the display.

Trigger options

You can trigger on an edge or pulse width, on the AC line (50Hz in Australia, New Zealand and the UK etc), or via an external input. The edge triggering can function in video, slope or the so called "alternative" mode. The latter makes the trigger alternate between the two channels, which can be very useful for stabilizing waveforms of very different frequencies.

The trigger options are comprehensive, allowing you to choose the pulse width, edge polarity, to sync on odd or even video fields etc. If in doubt, you can always use the AUTO SET feature which has its own button. This sets the parameters automatically to obtain the best display.

In this DSO, the AUTO SET feature can be customised so that it optimises the display for one or many cycles of a waveform. A nice feature of the AUTO SET is that it can be undone, if you decide it's not exactly what you were hoping for.

All the usual modes are available and you can display traces in XY or YT mode. The latter is the usual time on the X-axis and voltage on the Y-axis mode, while the former plots the channels against each other and is useful for seeing phase differences among other things; the display will be a Lissajous figure.

Acquisition and triggering

You can easily set up the triggering by using the "SET TO 50%" button. This has the effect of setting the trigger point to half of the signal amplitude. This is a good starting point for then customising the trigger condition.

Noise reduction

The ADS1102CA can average up to 256 waveforms in real time and display the result, reducing the effects of noise. You can also enable a digital filter which can be configured to work as a low pass, high pass, band-pass or band-reject filter, with configurable cutoff frequencies.

Peak detect sampling can also be enabled, to see very fast glitches in a waveform. The peak detect mode will trigger on glitches down to a mere 10ns.

MATHs functions

This oscilloscope has the basic MATHs functions that would be of the greatest use: you can add, subtract and multiply two waveforms and display the result.

You can also perform an FFT (Fast Fourier Transform) on a waveform and have it displayed on the screen. The FFT can work in one of four modes, each suited to a particular task: Rectangular, Hamming, Blackman and Hanning. The FFT has a 10 x digital

Fig.3: screen grab showing the FFT (green trace) applied to a square wave (yellow trace). The FFT trace can be displayed either superimposed on the main display, or in a split screen mode (as shown here). In this shot, the frequency domain stretches over the whole analog bandwidth of 100MHz. The vertical scale is in dBVrms, decibels with respect to 1V RMS.

Fig.4: all the measurements which can be displayed for a waveform, shown at once. The waveform itself will be concealed behind the measurements display but you can see all the vital statistics. When a measurement is unavailable, it is shown as a string of asterisks. The frequency counter is shown at the bottom right corner and is separate to the measurements.

zoom (in the frequency domain) and you can choose to have the FFT superimposed on the main display or appear separately in a split screen configuration. See Fig.3.

Cursors

There are two vertical and two horizontal cursors that can be used to measure parts of a captured waveform, with up to two cursors used on a waveform at any one time.

The cursors can be applied to the MATHs waveform, as well as to a previously "stored" waveform (one of the so-called "reference" waveforms). This is useful if you wish to examine in detail a portion of a waveform.

Each cursor can be positioned using the "universal" knob. It can work out the difference between the two cursors, or get the reading at that point.

Automatic measurements

You can enable measurements on a waveform from a comprehensive set; they are displayed superimposed on the LCD, as shown in Fig.4. The following are among some of the measurements: frequency, amplitude, RMS voltage, positive pulse width, fall time, duty, overshoot, true RMS, mean voltage.

When you select to display "All Measurements", the measurements are in three groups. You can choose to enable or disable all the voltage, all the time or all the "delay" measurements. The first two are self-explanatory. The "delay" measurements include phase difference, time between first falling edge of first waveform and last falling edge of second waveform, etc.

The back panel houses only the pass/fail out socket and RS-232 and USB ports. Mains power connects via an IEC socket under the rear.

Counter

Although you can measure the frequency of either of the two channels, for best accuracy you can use the built in frequency counter with up to 6 significant figures of resolution.

Pass/Fail mask

The ADS1102CA has a simple pass/fail feature that is very useful for testing hardware. You can define a "pass mask" and get a simple PASS/FAIL response for input waveforms (see Fig.5).

If the incoming wave falls outside the mask, you can configure a PASS or FAIL response. The results are tallied and displayed.

Delayed mode

If you enable the "Delay" option in the timebase menu, the display changes to a split screen, with the lower half of the screen displaying a "zoomed" are of the waveform (you reach this mode by pressing the "Hori Menu" button just below the timebase knob). You choose the zoom area (which is shown in the top half of the screen) by using the timebase knob and its smaller, offset knob to move horizontally in the time domain (see Fig.6).

This can be useful for going back and forth in time from the trigger point and it allows you to see more detail of the waveform.

USB host port

The front panel also has a Type A USB host port that can be used to

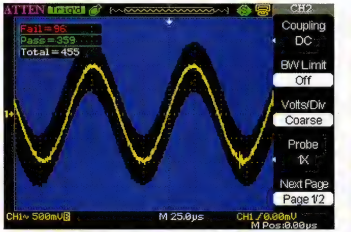

Fig.5: the PASS/FAIL feature. Given a waveform, in this case a simple sinusoid, a PASS/FAIL mask can be created (shown in blue). Subsequent waveforms can be compared against this mask. If they lie outside of the mask, you can configure the oscilloscope to produce a FAIL response. This makes repetitive testing easy. The number of pass/fail results are shown on the display.

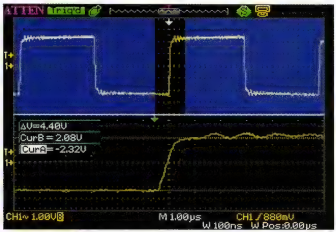

Fig.6: the delayed mode allows you to scroll back and forth and zoom in on a waveform in the time domain. Here the top half of the display shows the actual waveform, and the non blue area represents the selected portion of the waveform that is displayed in the bottom half of the display. We can see better detail of this "square" wave's rise time. The waveform rises 4.40V within a 1us or so.

Serviceman's Log – continued from p48

This time, after everything had been plugged back in, there were no beeps and the scooter moved accordingly when the controls were operated.

The lack of circuit diagrams can be a real hindrance in service work. If Dad buys another mobility scooter to fix, I hope he gets one with the same electronics as the one we've just repaired, otherwise I foresee more headaches.

Intermittent car radio

This next story is from F. W. of Airport West, Victoria, who recently locked horns with an intermittent car radio problem. Here's his story . . .

In 2001, I bought a 1988 Nissan Skyline R31 GTS special vehicle which was in a run-down state and in need of some major rebuilding. My licensed aircraft engineer background enabled me to do most of the work myself and I literally rebuilt most of the vehicle. Among other things, this involved rebuilding the engine, transmission and differential, plus the complete removal of the dashboard and instrument panel to replace a leaking heater core.

The rebuild took about four months and when it was finished, the car started and ran perfectly. However, there was a puzzling fault in the vehicle's radio.

The car had the original radio/tape deck in it and the radio had intermittent reception. For example, if I started the car in the garage, the reception would perfect on both AM and FM. However, as soon as I had been driving for some time, the reception would suddenly fade away to almost nothing, sometimes with some static.

Because the unit only had a tape deck and I wanted to play CDs, I decided to scrap it and fit a more modern radio with a CD player. At the same time, I was also hopeful that this would cure the reception problem.

And so a new Panasonic radio/CD player with all the bells and whistles was fitted and it initially appeared to work fine. Unfortunately, as soon as the car was driven on a warm day the reception disappeared, just as it did with the old radio. The time had come to really sort this problem out!

With the engine running, I checked the supply line to the radio and found this to be at about 13.5V, as expected. The earth connections were then checked and these also proved to be OK.

Next, I removed and carefully inspected the roof-mounted antenna. I also checked the continuity of the antenna cable, checked for shorts between its inner core and the braid and checked the earth connection on the roof. No faults were evident.

And then something strange happened. With the advent of winter, the problem suddenly disappeared and was all but forgotten until the following summer when it just as suddenly reappeared. By now it was beginning to dawn on me that the problem was temperature-related but what could it be?

I would like to say that the problem was found by my years of troubleshooting expertise. However, it came down to a simple car wash to find the fault. I was at my local car wash and wanted to listen to some music from the radio while the car was being hosed. As a result, I turned the volume up so I could hear it with the windows up.

As I washed around the roof-mounted antenna, the volume of the radio varied up and down dramatically. I then found that moving the antenna by just a small amount duplicated this effect so when I got home, I removed the antenna and repeated all my previous antenna checks. To my amazement, I found nothing.

It was only then that I thought to look down into the hole in the roof where the antenna fitted. When I did, I noticed the end of a screw which held the central internal mirror base to the roof. This screw was too long and was within a bee's whisker of touching the antenna base.

Obviously, as the car roof heated up, it expanded just enough to allow this screw to touch the antenna's base. I fitted a shorter screw to the mirror base and the problem was solved.

The mirror was one thing that I had not removed during the rebuild so I suspect it was like that from new. SC

Atten ADS1102CA Digital Storage Oscilloscope: continued from page 95

connect a USB flash drive. This allows you to store waveforms, settings and take screen grabs.

You can also connect a PictBridge compatible printer directly using a Type B USB socket on the back panel. There is a dedicated button for printing screen grabs on the front panel. You set the printing mode (ink saver on/off), layout (portrait/landscape) and paper size in the menu system. This bypasses the need for a PC to print; you can obtain a hardcopy immediately from your printer.

The USB port also allows you to connect this DSO directly to a PC and use the supplied Windows software suite, EasyScope, to control the oscilloscope.

The only other connectors on the back panel are the IEC power socket, a serial port and an additional BNC connector that is used for pass/fail testing, as described earlier. Note that the firmware can also be upgraded using a USB flash drive.

Customisation options

Interestingly, the waveform interpolation can be switched between sin(x)/x (commonly used and optimal for reconstructing waveforms) and linear (linear interpolation simply connects points using a straight line).

There is also a comprehensive help guide in a number of languages, including Chinese, Japanese, Arabic and Russian (as well as English!) and a selection of up to four "skins" which vary the look of the display.

In summary, the Atten ADS1102CA DSO is a portable, affordable DSO with many good features and is very capable. It is supplied with two switchable x1-x10 passive probes, good for 100MHz, user manual (CD), Windows EasyScope software (CD), IEC power cable and USB cable.

Where from, how much?

The ADS1102CA is available from from Wiltronics (**www.wiltronics.com.au**). It costs $A760 plus GST.

Contact: Wiltronics Research Pty Ltd, Unit 4, Corner Ring Road & Sturt St, Ballarat Vic 3350. Phone (03) 5334 2513 or Free Call 1800 067 674. Email: **sales@wiltronics.com.au** SC

PRODUCT SHOWCASE

Recessed wall plates suit power, AV, comms, home theatre etc

WES components' new recessed wall plates solve a major problem for electricians, comms and audio installers and handymen, when space just isn't available for standard surface-mount outlets.

Compatible with all major brands of wall outlets, they are suitable for use in 70mm or 90mm plaster board wall cavities (brick models coming soon).

They can be used on new installations or retrofitted to existing plates and allow the appliance (eg, large-screen TV, dishwasher, oven, etc) to be installed virtually right on the wall.

They're also great for bedside tables and other furniture where you need an outlet behind but don't want a gap back to the wall.

Easy to install, they're made of a high quality heat-resistant plastic with metal bracket.

White in colour, the trade price is $26.95 (inc. GST) [Cat WP-REC1]

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Tel: (02) 9797 9866 **Fax:** (02) 9716 6015
Website: www.wes.net.au

Opus One Wizard touchscreen controller – now $400 off!

It's much more than just another remote control device: it can virtually automate your home – even 100 devices or more.

Home theatre, screens, security systems, air conditioners, lighting, blind controllers . . . literally, anything with an infrared or RS-232 interface can be controlled from the Opus One Wizard touchscreen.

The 3.5-in TFT screen has an extensive selection of pre-loaded icons. Simply choose the ones you want and it communicates with those devices.

And the best part: right now the Opus One Wizard from Altronics (Cat A 0979) has a massive $400 saving, which means home automation just became a whole lot less expensive!

Contact:
Altronic Distributors Pty Ltd
PO Box 8350, Perth Busn Centre, WA 6849
Tel: 1300 780 999 **Fax:** 1300 790 999
Website: www.altronics.com.au

Fluke's "Stik" thermometers – tougher & safer than glass!

New "Stik" digital thermometers from Fluke Calibration are tougher and safer than mercury-filled glass thermometers, so are intrinsically safe in potentially explosive atmospheres.

Although mercury-filled glass thermometers are accurate and repeatable, they are fragile and pose the risk of a mercury spill, which can endanger the environment and human health.

The 1551A and 1552A "Stik" Thermometers provide a highly precise and durable digital replacement for mercury-in-glass thermometers. They are more durable and can be used reliably outdoors or on the production floor.

The 1551A covers a temperature range of -50°C to 160°C, while the 1552A ranges from -80°C to 300°C, with an accuracy of ±0.05°C.

The stainless steel probe and digital readout are fixed together and calibrated as a system. The accuracy specification is easy to understand since it includes all uncertainty components, including drift, for up to one year. Unlike competitors, the large backlit LCD display rotates through 90°, making it easy to read from any angle.

Data logging to internal memory of up to 10,000 time-stamped measurements is optionally available.

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Unit 26, 7 Anella Ave, Castle Hill, 2154
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Rugged 750 Lumen Torch uses a single CREE MC-E X-Lamp LED

As the power of LEDs continues to increase, they're finding their way into more and more applications that were once the domain of incandescent globes.

This new LED torch from Jaycar Electronics has a single MC-E CREE X-Lamp giving a maximum output of 750 lumens (with high, medium and low output settings) and is of rugged aluminium construction, sealed against the elements at both ends with silicone gaskets.

This is the kind of torch you need for serious outdoor activities: camping, boating, emergency rescue departments, police, military . . . you name it. It takes four "D" cells.

Available now from all Jaycar stores (Cat ST-3451), it's priced at $99 ($NZ119). *sc*

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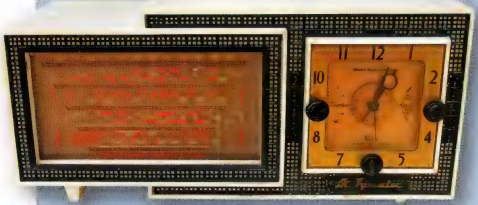
PO Box 107, Rydalmere NSW 2116
Order Tel: 1800 022 888 **Fax:** (02) 8832 3188
Website: www.jaycar.com.au

Vintage Radio

By RODNEY CHAMPNESS, VK3UG

The STC A5150 5-valve mantel clock radio



Clock-radio mantel receivers were all the rage in the 1950s. This month, we take a look at the STC (Standard Telephones & Cables) A5150 clock-radio which used a conventional 5-valve superhet circuit but was housed in a rather unusual cabinet.

MANTEL RECEIVERS for use in the kitchen had become quite popular by the late 1940s, with both economy 4-valve units and more up-market 5-valve units being sold. However, as that market became saturated, manufacturers looked at adding extra features to keep buyers interested. Electric clocks had by then been around for some time, so the manufacturers hit on the idea of incorporating them into mantel receivers.

One result of this was that such sets could now also be used as bedside receivers, since they invariably included an alarm system. So instead of the user being awoken by an alarm clock, they could instead by roused by the radio automatically switching on.

In addition, the clock typically switched a mains socket on the back of the chassis. A bedside lamp could then be plugged into this socket, the idea being that the lamp would switch on at the same time as the radio.

Another common feature was the "sleep" or "slumber" mode. This typically allowed the user to leave the radio on but to set it so that it would automatically turn off up to an hour later. Of course, this all worked as long as the mains power didn't go off during the night!

The STC A5150 clock radio

STC's A5150 clock radio was first produced in 1955. It is a typical 5-valve mantel/bedside receiver with an in-built Smiths electric clock. As an aside, it's worth noting that most manufacturers built two versions of their mantel receivers during this period – one with a clock and a cheaper version without a clock. As far as I can determine, the receiver-only version of this unit was designated the A5140, which came out in 1954.

A feature of the A5150 is its unusual but interesting plastic cabinet. In fact, it looks like two cabinets grafted together!

The lefthand end of the cabinet carries a large rectangular dial scale, while the tuning gang is on the chassis immediately behind the dial. The tuning control is at the righthand end of the cabinet and this drives a long brass shaft which runs right across the chassis and through a bracket mounted on one end of the gang (see photo). This shaft then drives the dial drum and the dial pointer via a dial cord assembly.

It's an unusual arrangement but is still very effective.

The loudspeaker is located immediately behind the dial. This was a fairly common arrangement in mantel receivers as it saved quite a bit of space. The loudspeaker has an oval-shaped frame and is a permanent magnet type with a 3Ω voice coil.

The clock is mounted to the extreme right of the cabinet and it's interesting to note that the same cabinet was used for the A5140, ie, the model without the clock. In fact, the A5140 has the speaker mounted where the clock goes in the A5150. This got it out from behind the dial and presumably resulted in slightly better sound quality. Only the front escutcheon differs between the two models; the rest of the cabinet is identical.

Inside, the chassis is quite tightly packed with components in some places, although access isn't difficult. All the controls for the receiver come out at the righthand end of the cabinet. This frees up the front of the set for the

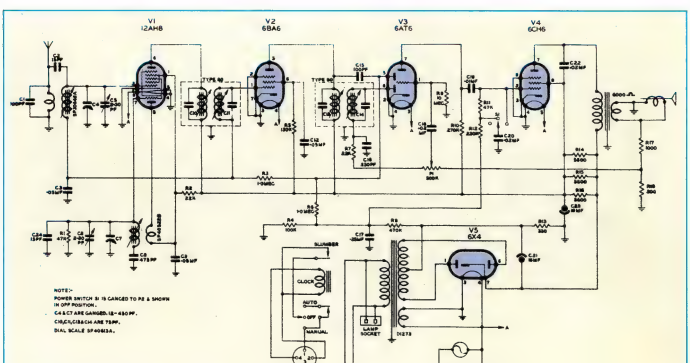


Fig.1: the circuit is a fairly conventional 5-valve superhet design, although the valve types differ from those generally used by other manufacturers.

dial scale and the clock and ensures that the controls are well spaced.

Circuit details

Let's take a look now at the circuit – see Fig.1. It's a 5-valve superhet design and is a typical STC radio circuit for the era. However, it's slightly different to the run-of-the-mill circuits from other manufacturers, the differences relating mainly to the valves used.

The antenna section employs two tuned circuits: (1) a fixed tuned circuit which includes the primary of the antenna coil; and (2) a variable broadcast-band tuning circuit which tunes from 530-1620kHz. The fixed tuned circuit is broadly tuned below the broadcast band and ensures good performance with the shorter antennas that were commonly used in the 1950s and 1960s.

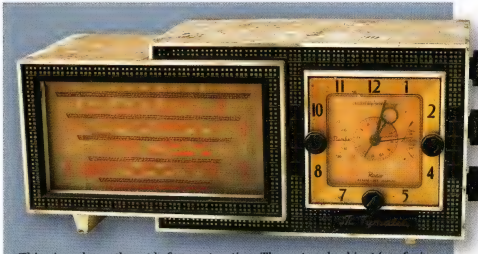
These antennas usually consisted of a 7-metre length of wire that was run around the picture rail in the room.

The oscillator circuit is quite conventional. However, unlike other circuits, it doesn't have an oscillator blocking capacitor as the tuning capacitors in this section do that job. The 47kΩ oscillator grid leak resistor is wired across the tuned circuit.

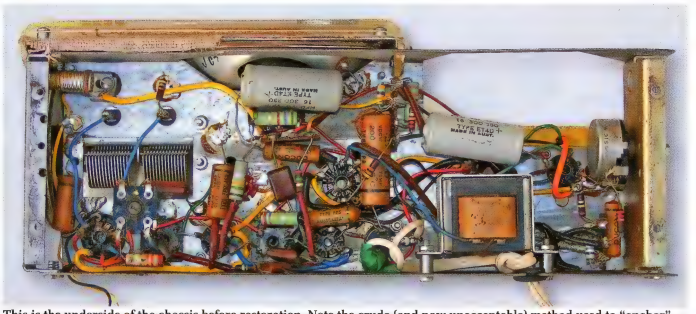
The converter valve (V1) is a 12AH8 and is rarely seen in sets other than STC models. It is similar to a 6AE8 or 6AN7 but also has a 12V centre-tapped heater which makes it more versatile, particularly for car radio work.

The 455kHz signal at the plate of the 12AH8 is fed to the first IF (intermediate frequency) transformer and then applied to V2, a 6BA6 IF amplifier stage. The amplified IF signal is then applied to the second IF transformer and fed to a detector diode in V3. Valve V3 is shown on the circuit as a 6AT6, although the higher gain 6AV6 was also used in some chassis and is in fact fitted to this particular set.

The resulting audio signal from the detector is fed via resistor R7 (at the bottom of the second IF transformer) to volume control P1. It is then fed via a capacitor to the grid of V3 and



This view shows the set before restoration. The restored cabinet (see facing pages) came up quite well although it does have a couple of small cracks due to heat from the valves.



This is the underside of the chassis before restoration. Note the crude (and now unacceptable) method used to "anchor" the mains cord. The latter will be replaced with a correctly anchored 3-core flex so that the chassis can be earthed.

amplified. The amplified plate signal is then AC-coupled to the grid of V4 (a 6CH6), which is a high-gain pentode audio output valve.

V4 in turn drives a 6kΩ speaker transformer. Most speaker transformers have either a 5kΩ or 7kΩ plate impedance winding which suits valves such as the 6AQ5 and 6M5 respectively. The 6CH6 is slightly different in its characteristics and has higher gain as well.

The circuit shows a resistive divider across the speaker transformer's secondary which applies negative feedback to the grid of the 6AT6 (V3), ie, via the volume control and grid-coupling capacitor. In this set though, the negative feedback had been left disconnected (more on this later).

Delayed AGC

As with most similar sets of the era, the circuit has delayed automatic gain control (AGC). The AGC diode in the 6AT6 (ie, at pin 5) operates at a fixed bias and so this diode does not conduct until the applied IF signal rises above this level.

Note that the AGC diode is fed via a mica capacitor from the plate of the 6BA6 (V2), so that it receives a larger signal than is fed to the detector diode. This results in a simple but very effective delayed AGC system.

Power supply

The power supply is conventional for the era and is based on a 6X4 full-wave rectifier (V5). Note that there are no filter chokes as by this time the latest (higher capacitance) electrolytic capacitors and cheap carbon resistors were more than adequate for filtering the high-tension (HT) line.

The back bias for the circuit is generated across resistor R13 (330Ω) and is between 14-16V. In addition, three parallel 5.6kΩ resistors (R14, R15 & R16) act as part of a decoupling circuit between the plate circuit of the 6CH6 and the HT rail to the rest of the receiver. Finally, a 2.5V bias voltage for V1, V2 & V4 is derived from a voltage divider across the back-bias resistor (R13).

Clock interface

The clock is plugged into the chassis via a 4-core lead. It is a synchronous clock, so its timing is locked to the mains frequency.

In operation, the receiver can be switched on or off using the "Auto-Off-Manual" switch. In the "Auto" position, the clock mechanism closes a set of contacts at the set time to switch the radio on. In addition, if a lamp is plugged into the outlet socket at the back of the radio, this will come on as well – or at least, that's what the circuit shows.

In this particular receiver, however, no lamp socket has been fitted. Either that, or all traces of it have been removed by a previous restorer or serviceman.

One advantage of a valve clock-radio is that it comes up to volume much more gradually as the valves warm up than a solid-state device. This makes it much more pleasant to use as a bedside alarm.

Restoring the cabinet

Unfortunately, the set featured here had not had an easy life and its cabinet looked quite neglected. In particular, a previous owner had obviously used the set as entertainment while they did painting. As a result, numerous spots of blue and white paint adorned the cabinet and the clock face, along with several sticky tape tracks.

Before restoring the chassis, it was necessary to remove both the chassis and the clock mechanism. This is done by first pulling off the three control knobs, removing the cabinet back (it's held on by four screws) and unplugging the clock mechanism. The chassis can then be removed by undoing four screws from the cabinet bottom, after which the clock mechanism is removed by undoing four nuts (one at each corner of the mounting plate) and removing the three knobs on the front of the mechanism.

It might sound like a complicated disassembly procedure but it's quite straightforward in practice and is certainly much easier compared to many other clock-radios of the 1950s.

Once all the parts had been removed, the cabinet and all six knobs were washed in soapy water. A nail-brush was used to get most of the muck

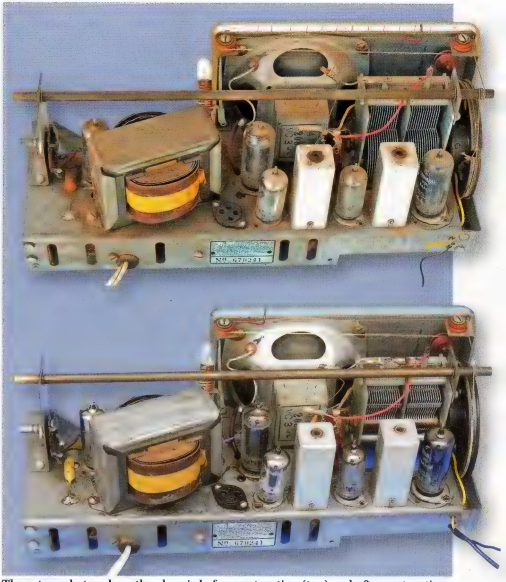
off both the inside and outside of the cabinet and was also used to scrub the flutes of the knobs to rid them of years of accumulated grime. The cabinet and the knobs were then rinsed with clean water and set aside to dry.

The next job was to clean the paint spots and sticky tape remains off the cabinet. I used a small single-sided razor blade to scrape the worst of the muck off, at the same time taking care not to scratch the plastic. The cabinet itself is white on the outside while the inside had been painted black. However, it had not been masked properly when this was done and so I also spent some time scraping away several areas of overspray.

Once this had all been done, the cabinet looked quite reasonable despite two small cracks in the plastic on the top. These had obviously occurred due to heat from the output valve and the power transformer. Fortunately, they were not too obvious and were not worth fixing.

Cracks or distortions in the plastic due to heat from adjacent parts were common in many mantel receivers. In this set, STC had endeavoured to minimise the problem by gluing a couple of pieces of metallic foil to the top underside of the cabinet, the idea being to reflect the heat back and disperse it as much as possible. This technique was only partly successful, as the cracks indicate.

Finally, the cabinet restoration was completed by polishing it with automotive cut and polish compound. This brought up the lustre quite well but this particular cabinet is still not in pristine condition despite the restoration work. Heat damage is the main problem.



These two photos show the chassis before restoration (top) and after restoration (bottom). A kerosene-soaked rag is good for getting rid of the gunk.

Chassis restoration

Unlike the cabinet, the chassis was in really good condition. There were no signs of rust but it did have a coating of accumulated dust and some wax on the top side.

After removing the valves, the chassis was dusted down using a small paintbrush. The wax spots were then lifted and scraped off using a flat-bladed screwdriver after which the chassis and most of the other above-chassis components were wiped with a kerosene-soaked rag to remove any remaining gunk. Once this had been done, the chassis looked quite respectable.

Next, the valves were cleaned with soapy water. I don't dunk them in the water though; instead, I gently rub the valve envelopes with a soapy finger to remove any grime. The valve markings were left alone though, since they are all too easy to remove. Once the valves were clean, I rinsed them with clean water and stood them on their pins to let them dry.

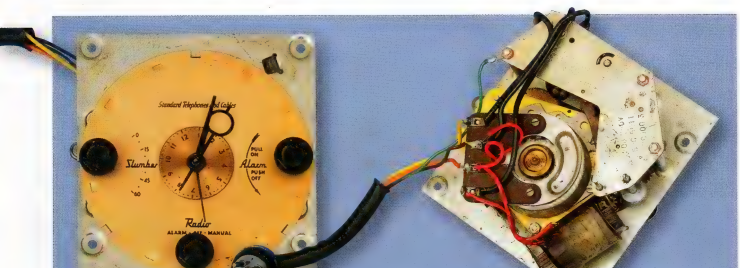
Clean valves look great in a receiver and this one was no different. Note, however, that octal valves must be cleaned in a slightly different way, to ensure no muck gets down into the base.

Now that everything was clean, the various pulleys and shafts were given a drop of oil to ensure they all operated smoothly. The tone control switch and all valve sockets were then sprayed with Inox to lubricate them and clean any corrosion off the contacts.

Fixing the circuit

It was now time to work on the circuit. I began by replacing the AGC bypass capacitor (C3), along with C18, C19, C20 & C22 in the audio section, as leakage in any of these will cause problems. This turned out to be a wise move because they were all quite leaky, particularly C3 and C19, the most critical items. These paper capacitors were all replaced with polyester units with similar voltage ratings. The only paper capacitor left in the set is C17, the back bias filter.

Next, I checked the resistors to make sure that they were all close their marked values. These were all OK except for R5, the screen resistor to the



The clock mechanism plugs into the chassis via a 4-way socket adjacent to the power transformer. Unfortunately, it no longer works because the teeth are missing from one of the gears, just after the motor.

6BA6, which was open circuit and had to be replaced. My guess is that this resistor's failure was the reason the set had been taken out of service many years ago, its owner deciding that it simply wasn't worth fixing.

Further checking also revealed that the negative feedback line from the bottom of resistor R17 (on the speaker transformer secondary) to resistor R18 was missing. In fact, it was impossible to determine whether this wire was ever there or not. As a result, I fitted a wire so that I could easily join these two resistors together later on. That way, I would be able to quickly check the receiver's performance with and without the feedback.

The speaker transformer was in good order with both windings showing continuity. However, I was disappointed to discover that the clock is beyond repair. The teeth have worn off one the gears, just after the motor, which means that the mechanism is unable to rotate.

I also encountered problems with the mains cord. **The original has been anchored by tying a knot in the lead just inside the chassis but that's completely unacceptable these days.** Unfortunately, it's impossible to fit a 3-core mains lead complete with cable clamp at its present entry point, as this will interfere with the speaker transformer.

One way around this would be to drill a hole in the chassis straight through the ARTS&P sticker and fit a 3-core mains lead there. However, I don't want to do that as it would spoil the authenticity of the restoration.

At the time of writing, I've yet to solve this problem but I'll probably end up moving the speaker transformer so that I can install and secure the new mains cord in the current location. A 3-core lead will enable me to earth the chassis, in the interests of safety.

Leakage checks

My next step was to check the mains transformer. This was done by checking the isolation between its frame and the primary and secondary windings using a 1000V insulation tester. This revealed no signs of any insulation breakdown.

In fact, I've found the mains transformers in old radios to be remarkably reliable although the occasional one is defective. However, just because faulty mains transformers are rare, it doesn't mean that we can be complacent. They should all be tested using a high-voltage insulation meter before power is applied, as the consequences on not doing this could be fatal.

A resistance check between the HT line and the chassis also showed very little leakage. I then connected my electrolytic capacitor reformer to the HT line and set it to the 250V range. After a few minutes, the voltage on the HT line rose tp about 250V, indicating that the electrolytic capacitors had reformed. By then turning the reformer off and on a few times, I could see that the capacitors charged within a second or so, so they were probably OK.

Getting it going

Once all the above tests had been completed, the valves were reinstalled and the set switched on. The HT line and several other voltages were then monitored as the set warmed up and these all proved to be correct. What's more, there were no signs of any trouble with any of the valves, such as internal sparking.

Once the set had warmed up, there was a slight hum from the speaker and this indicated that the audio stages were probably working. However, I was unable to hear any stations, even after tuning right across the dial.

I fired up my signal tracer and this detected RF signals at IF and signal frequencies, so those sections seemed to be working correctly. It was then that I discovered that the 6AV6 wasn't lighting up, so I wriggled it in its socket and shortly afterwards was rewarded with noise from the speaker. Obviously the Inox hadn't quite cut through the corrosion on the valve sockets until I wriggled the valve.

I then tried tuning the set again and this time stations came in right across the dial.

It was now time to try the negative feedback circuit. I connected it and was immediately disappointed with the quality of the sound. I looked at the audio waveform from the signal

generator's detected RF signal on the oscilloscope and I could see that the resulting sinewave was much less distorted when the feedback was disconnected. What's more, there was no sign of any supersonic oscillations and the bias on the 6CH6 was normal.

In the end, I left the feedback disconnected in order to extract the best performance from the receiver.

Alignment

By now, the performance of the receiver was quite good. Even so, it was worth checking the alignment to ensure that the receiver was operating to its full potential.

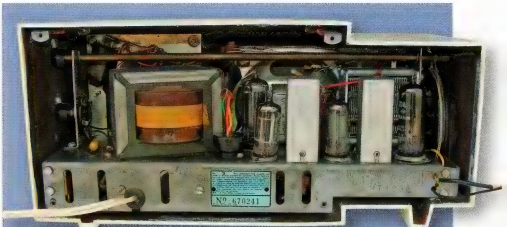
I began by connecting the output of my Leader LSG11 signal generator to the antenna terminal. The tuning gang was then closed and I tuned the signal generator across the likely IF frequency of 455kHz and adjusted its output level to get a reasonable signal through the receiver.

The set gave its best response at around 455kHz, so I adjusted all four IF transformer tuning cores with an insulated alignment tool (a modified plastic knitting needle can also be used for this job) to peak the response. As I did so, I kept reducing the generator's output so that the signal was a little noisy as each coil was peaked. This method ensures that the IF stage is correctly adjusted for peak performance on weak signals.

Having done this, the performance was quite good and it was time to align the receiver's front end. This alignment can be done with instruments connected to the audio output or to the detector. However, I find that I can accurately align receivers by listening for the best quality audio signal with the lowest input signal practical.

The front-end alignment was out a little so I fed in a 600kHz signal from the generator and adjusted the oscillator coil until this signal was heard at the 600kHz marking on the dial. I then tuned to the high-frequency end and found that a 1400kHz signal from the generator was heard slightly further along than its correct location on the dial. This was corrected by removing a couple of turns of wire from the wire-type trimmer capacitor.

The final step in the alignment was to adjust the antenna circuit. Tuning to the low-frequency end of the dial, I found that I needed to adjust the tuning slug considerably to get the best sensitivity. I then tuned to the high-frequency end and found I had no adjustment available, as the trimmer capacitor was missing from the set!



The chassis is a neat fit inside the plastic case. The case has cracked in a couple of places due to heat build up, despite the valves being some distance away from the sides and the top.

As a result, I connected a trimmer that I had available but found that even with the trimmer adjusted to minimum, I couldn't peak the performance at that end of the dial. In the end, I found that I had to compromise with the low-frequency core adjustment by moving it slightly off peak performance. This then allowed me to adjust the trimmer for good performance at the high-frequency end of the dial.

I suspect that the problem is connected with the padder capacitor used in this set. This has a value of 475pF which is quite a bit higher than the usual value of about 425pF. However, if I were to change the value of the padder, many of the dial markings would be incorrect, so I left it alone.

Because of this, I had to accept that I couldn't tune the set for maximum output. However, it is still a good performer and the quoted sensitivity of 10μV means it is no slouch in this aspect.

Odds & ends

The previous owner had altered the mains input wiring by bypassing the on-off switch on the clock. However, even though the clock no longer worked, this switch could still do its job so I rewired it back in series with the mains supply.

Before plugging the set into the mains, I clipped my multimeter test leads to the switch contacts and checked its operation. To my surprise, I found that it was quite intermittent.

My first thoughts were that the contacts must be dirty so I cleaned them with some fine wet and dry paper. Unfortunately though, that didn't fix the problem, the multimeter intermittently varying from zero ohms to open circuit when the switch contacts were closed.

I eventually tracked the problem down to a well-disguised dry joint on one of the switch terminals. This dry joint had obviously been there from the time the radio was made, although it may not have started giving problems until some years later. It also explains why the previous owner had bypassed the switch.

As a final check, I decided to measure the set's power consumption. The clock mechanism drew just 1.25W while the total power consumption with the receiver operating was 36W.

Summary

The circuit of the STC A5150 clock-radio is quite conventional and it works well, although there are some problems with the negative feedback network and the alignment of the antenna tuned circuit. Despite these problems, the sensitivity and the audio quality are both quite good. It's a shame that the clock has a worn out gear, although a friend has indicated that he has a clock that may suit the set.

As stated earlier, STC did things a little differently. The A5150 is certainly not the most awe-inspiring receiver around but it is still an interesting set that I am happy to have in my collection. SC

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High mains voltage an equipment hazard

A mate of mine commented about the mains being slightly high at 257VAC. We really should look at a project to stabilise the AC or limit potential rising AC voltages.

I remember many years ago a device with two transformers connected back-to-back, ie, 240V : 24 : 240V and it had some sort of simple ferro-resonant 24V DC circuit which affected the 240VAC output. OK, so it was not rocket science and but it sure took care of the ups and downs. (R. B., via email).

● Ferro-resonant AC voltage regulators are still be best way to go, particularly as they also have the benefit of cleaning up the AC waveform to some extent. We are not sure whether you can still purchase such products but they would be very expensive. We have also seen AC voltage regulators that were based on servo-controlled Variacs. They work extremely well but they have a relatively slow response to sudden changes in the mains voltage. Again, such a product is likely to be very expensive.

Most equipment should be able to handle wide variations in the mains voltage but that is clearly not always the case which is why we have produced the Mains Moderator project featured on page 66 of this issue.

Monitor for lithium-ion battery wanted

I am looking for something to monitor a Li-ion battery and to disconnect the load if the battery falls below 10V. I did find the Universal Voltage Switch project (from SILICON CHIP's Performance Electronics for Cars, 2004) but it required an additional 12V supply. I need something that operates off the monitored battery only. (M. B., Bedale, UK).

● The Universal Voltage Switch project is not really suitable for disconnecting a battery because it uses a relay to do the switching and this would tend to discharge the battery itself, even without considering the load the battery is connected to.

We have published two battery protectors in SILICON CHIP: first, the Micropower Battery Protector from July 2004 that can be set to switch off power from the battery at a preset voltage. This circuit draws 20μA. Second, the Battery Guardian from May 2002 which performs the same function but with larger batteries and larger loads. Its current drain is 2.5mA.

Battery eliminator for vintage radio

Have you ever described a battery eliminator for vintage battery sets? I have sets that need 1.5V and 90V. and another that requires 2V and 135V. At the moment, I am using a series of 9V batteries but for 135V, 15 batteries is a bit over the top. I would prefer a supply that runs off batteries; maybe a gel cell. (P. C., via email).

● We described a Valve Preamplifier power supply in November 2003. This could produce up to around 260V DC, although the voltage can be adjusted with a trimpot from between 39V to above 260V. The lower voltages can be obtained from cells as these presumably would require more current.

Programmable ignition system on Ducati V-twin

Could you let me know if there is a workaround to let me get a signal to the coil driver from the first input signal from the two Hall Effect sensors (HKZ 101) that I am using to trigger a pair of Programmable Ignition Systems (SILICON CHIP, March, April & May 2007)?

The system is fitted to a kick-start V-Twin Ducati and runs two completely independent ignition systems; one for each cylinder. The systems appear to work OK but I have no way to turn the engine at a constant >72 RPM prior to the first cylinder firing.

I neglected to properly comprehend the implications of a minimum input frequency of 0.6Hz. I figure I could most probably put a pulse generator on the input to the Programmable Ignition System, to make three or four pulses, triggering from the Hall Effect sensors and activated and deactivated by a start/run switch.

I guess I would have to keep the

Ultrasonic Cleaner Makes "Snufferling" Noise

My Ultrasonic Cleaner project (SILICON CHIP, August 2010) does not work. No bubbles. The power LED is on. There is 5V between pins 1 & 8 and 5V on pin 4 which drops to zero when the button is pushed. The timer works and the running LED flickers a bit as it is mainly on.

The gate voltages are 1.3V and the Mosfets are hot. With an ambient temperature of 30°C, Q1 is 70°C and Q2 is 77°C. The tranny frame is 49°C.

My CRO is no good for high voltages, so I looked at the transformer primary between each drain and earth. The frequency in both modes is about 40MHz. The transducer makes a weak "snufferling" noise. Any suggestions, please. (P. L., via email).

● The Mosfets and transformer should not run hot. Check that the transformer is wound correctly and that the zener diodes and diodes are oriented correctly. The cleaner works best from a 12V lead-acid battery so that the transducer can be driven with maximum peak power.

If gate voltages are only reaching 1.3V this would prevent their turning on. Presumably this value is a multimeter DC measurement instead of an oscilloscope measurement. The frequency of operation should be between 20kHz and 40kHz rather than the quoted 40MHz.

Noisy Transformer In Class-A Stereo Amplifier

I recently built the 20W Class A Amplifier from a kit supplied by Altronics. Overall, the kit was very good; the instructions and diagrams excellent. It went together well. The design is amazing. Well done.

Unfortunately, the power transformer has a loud audible buzz as soon as the bias current is set to specification. This is clearly audible over quiet music, even with the lid on the chassis. It makes it difficult to enjoy the obviously extraordinary design. In your distortion measurements, you did not include the nett effect of mechanical – including transformer buzz. This must be taken into consideration when discussing the effective distortion and signal-to-noise ratio.

This transformer is a real problem. I contacted Altronics and they gave me a copy of an explanatory letter from SILICON CHIP. Where do I go from here? Should I use a higher-spec transformer, one that is better made, one that is not working as hard?

Is the prototype power transformer better than what is being shipped in the kits? (J. R., via email).

● We can assure you that the buzzing from our prototype transformer was quite low – as indicated in the letter you received from Altronics and signed by Leo Simpson. Clearly your transformer is noisier. One possible way to quieten the buzzing from the transformer windings is to fill the centre of the toroid with potting compound, while still leaving a clear centre hole for the mounting bolt.

This method is used by Harbuch Electronics (Phone 02 9476 5854) on some of their toroidal transformers. In fact, this has been discussed with Altronics as has the possibility of using a physically larger transformer. Our suggestion is that you try the potting method.

By the way, we do consider mechanical noise in assessing amplifier performance. It is only in the case of the 20W Class-A Amplifier that buzzing from the power transformer is ever an issue. This is because of the high fixed load on the transformer.

Another solution would be to put the transformer in a separate case, as we did for the earlier 15W Class-A Stereo Amplifier featured in the July & August 1998 issues of SILICON CHIP. However, we are reluctant to advocate this approach because it can cause hum problems due to induction into nearby signal sources such as DVD or CD players.

pulse frequency below the minimum advance RPM setting and also fast enough to avoid retarding the first output signal too much. Or possibly I could run a separate start ignition that just uses the Hall Effect sensors and the coil drivers and bypasses the Programmable Ignition System until switched to the run position.

Either way, they don't sound like an elegant way to address the problem. If you have any suggestions, I would be happy to hear them. (D. D., via email).

● You could use a disk that has twice as many trigger lobes (evenly-spaced). That way there would be a wasted spark on the exhaust stroke but the minimum RPM would be halved.

In addition, we recommend that you set the low speed response (Response to low RPM setting) for use at the kick start RPM. That way, timing is solely set by the Hall Effect disk positioning. The ignition will then fire when the Hall effect is triggered and so will fire more reliably compared to the normal settings.

Solar/electronic remote gate opener

I would like to make a solar and electronic property gate opener, either with sliding or 2-panel swing gates. Have you ever produced a project of this nature or will you do so in future? (B. V., Drysdale, Vic).

● We published a garage door opener in April & May 1998. The mechanical details could possibly be adapted to a gate opener but the electronics for this project is now outdated.

Suitable remote controls are available from Oatley Electronics (**www.oatleyelectronics.com**) as a kit. Alternatively, the rolling code transmitter and receiver from August and September 2009 could be used. We also had an article on remote-controlled gates in the August 1997 issue.

Adapting the CDI to wasted spark operation

I found your article on how to build "A High-Energy Capacitor Discharge Ignition System" published in the September 1997 issue. My questions are: (1) Can the circuits be modified to work with a "trigger wheel" sensor on a 6-cylinder engine with COP coils (six coils)?

(2) Can two more coil circuits be added and use "wasted spark" to fire all six coils, two at a time 180° apart? (D. W., Hong Kong).

● The Multi-Spark Capacitor Discharge Ignition was designed for single coil ignition systems with a distributor for the spark. Ignition systems with multiple coils and a crankshaft position sensor are not particularly suitable for this CDI system.

It should be possible to use the coil driver signal from the multi-coil ignition to trigger a single CDI unit to drive one coil. A wasted spark system is suitable if the two cylinders are 180° apart and where the CDI has a separate high-voltage capacitor to charge each coil. The coil driver signal for each of the two coils would need to be ORed so that firing occurs with both coil driver signals.

With a 6-cylinder engine and wasted spark, three CDI units would be required, one for each set of coils.

DAB+ tuner regulator runs too hot

I have built the DAB+/FM Stereo Tuner and I like it a lot. I had one difficulty which maybe some other constructors might encounter. The Tuner would work as expected for 15 minutes or more but after a while would start distorting. When I removed the cover of the tuner it would work as expected for 30 minutes or more then start distorting as before.

After a fair bit of ferreting around I came to the conclusion that REG1 was getting too hot. So I used a bit of scrap U-shaped aluminium about 7cm long

Adapting A PC Power Supply As A Car Battery Charger

I was reading your article on the ATX power supply that you converted to a bench power supply in the January 2011 issue. I have a room full of these things and no car battery charger. After doing a Google search I found a circuit that used an ATX power supply with a DC-DC converter.

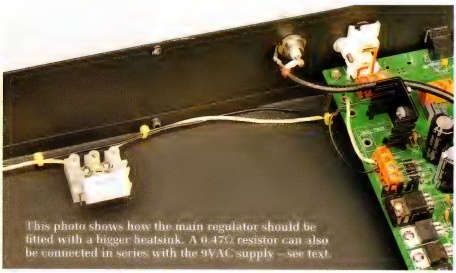
My question is how do I strip down an ATX power supply to make a DC-DC converter to up the output voltage of the ATX power supply so that I can charge a 12V car battery? (T. V., via email).

● Ideally, to use a PC supply as a battery charger, you would modify the feedback loop to bring the +12V output up to say +15V. Most likely this would not take any components outside of their ratings (the output filter capacitors are probably rated for 16V). This can then be stepped down easily to an appropriate voltage for charging a 12V lead-acid battery.

In fact, if we got really clever we could control the feedback ratio somehow, in order to make the PC supply do all the work of actually regulating the charge voltage and current. Then the only additional circuitry required would be to monitor the charge state and control the power supply.

Unfortunately doing this requires very specific knowledge about the design of the power supply and so the changes required for each model would be different. Our likely approach to take is to drive a DC/DC converter from the +12V output of the supply, to step that voltage up or down as appropriate to charge the battery. This requires extra componentry but it is the only approach we can think of that will work with any model of supply. The DC/DC converter would be adjusted by a microcontroller in order to provide 3-stage charging for the battery.

Note that a PC power supply does contain a number of chokes and transformers, high and low-voltage electrolytic capacitors and so on which are all useful in such a circuit and you could possibly salvage some of them to use in our proposed project. However, you would need detailed knowledge of the particular PC power supply to work out which components could actually be used.



This photo shows how the main regulator should be fitted with a bigger heatsink. A 0.47Ω resistor can also be connected in series with the 9VAC supply – see text.

to make a bigger heatsink. This solved the problem – no distortion and REG1 warm instead of darn hot.

I am using an internal 9V toroidal transformer which has a slightly higher voltage than the AC plugpack which came with the Jaycar kit, however the problem was also evident with the plugpack. The transformer is wired the same way as the plugpack (this is preferable because it results in less heat in REG1 due to half-wave rectification). The ambient temperature was no more than the mid-twenties so I think on hot days other constructors may also encounter this problem, even if the tuner works perfectly well at moderate temperatures. (B. D., via email).

● A number of readers have experienced similar problems and it is related to the input voltage to the regulator and the fact that we used half-wave regulation from the AC plugpack. This was necessary because AC plugpacks have only a single secondary winding and we needed positive and negative DC supply rails.

This means that while the average DC input voltage to REG1 is relatively high at around 9-10V it needs to be this high to cope with the 50Hz ripple voltage of about 3V peak to peak. So for the regulator to work well, it must have a minimum DC voltage of about 9V. At this voltage and with a current drain of up to about 800mA (depending mainly on the brightness of the LCD panel), the regulator is working well within its ratings, with the small heatsink that we specified.

The problem is that the voltage from AC plugpacks with a nominal voltage rating of 9VAC can be considerably more than 9V. We have run a series of tests on the prototype and have come up with a solution which should work well in a range of situations.

The first step is to stand the regulator (REG1) up so that it is vertical, to allow the fitting of a larger flag heatsink. The one we suggest is the type 6021 heatsink (Jaycar HH-8504 or equivalent). Second, we suggest connecting a 0.47Ω 5W wirewound resistor in series with the 9VAC output of the plugpack. The accompanying photo shows the arrangement, with the wirewound resistor connected to an insulated terminal block. Note that you will need to bend one of the fins of the heatsink to avoid contact with the adjacent terminal block on the PC board.

These two measures will considerably reduce the operating temperature of the regulator. Note that if you have low mains voltage, say around 230VAC, then the series resistor may not be necessary. So if readers experience problems with REG1 running too

How To Dim A Switchmode Halogen Transformer

I am trying to reconfigure your "Automatic Table Lamp Dimmer" featured in the July 2005 issue. I'd like to re-rate it to 400W. What Triac upgrade would you suggest?

I don't necessarily need the IR remote (IC2) but would rather operate it simply from a wallplate switch. I want on/off with a 4-second dwell each way and minimum brightness at an RMS voltage of 100V and maximum brightness at 200V RMS. I gather this is a leading edge trim.

What modifications would be required to apply to dimming electronic switchmode transformers for downlights, ie, my desired application. (S. J., Wollongong, NSW).

● The Dimmer will operate with a lamp of 400W but the Triac will require heatsinking. Changes to operate between 100V and 200V with just a switch would require software changes and a substantial rewrite would be necessary. The Touch-Light Dimmer from the January & February 2002 issues may be more suitable. However, you cannot use a dimmer with electronic switchmode transformers for 12V downlights unless the switchmode transformer is specified as a dimmable type.

hot, they should first fit the suggested larger flag heatsink and check its operation. If it still seems to be a trifle too warm, then fit the series 0.47Ω 5W resistor.

Possible dry joint on Venice 7 module

I am having trouble with the DAB+ Digital Radio Receiver, in particular the Venice 7 board. It appears to have cold joints. When you turn it on, you get distortion on both the FM and DAB+ channels. If you squeeze the Venice 7 board and the metal shield box on the board, the distortion disappears and you get perfect audio. Release the pressure and the distortion returns.

This all started happening after 30 minutes of perfect operation. Before that, if you used the remote to turn the unit into standby, you got clicks and hisses shortly after the flash of the "ACK" LED. I don't know if this is related or a separate fault.

Any help would be appreciated, especially, if need be, on how to remove the metal lid of the Venice 7 module so that I can resolder the joints. (D. P., Werribee, Vic).

● It does sound like you have a dry joint somewhere in the Venice 7 module although that is not certain. It could also be a bad joint on one of the pin header connectors (either on the Venice 7 module or the main board).

We wouldn't rule out the possibility that when you press down on the Venice 7 module, it is actually flexing the main board, resulting in what you observe. Try slightly flexing the main board during operation to see if this has the same effect on the symptoms, eg, press down near the Venice 7 module but not actually on it.

If this changes the behaviour then that suggests that it is something on the main board itself. You may want to also try pressing gently around IC3, IC4 & IC5 to see if the problem might be in that section. The clicks and hisses you describe may be a symptom of the same problem.

If your checks confirm that the problem is indeed in the Venice 7 module, we suggest that you remove it and reheat all the solder joints on the pin headers. If that doesn't fix it, then reheat all the pin header joints on the main board and all the solder joints in the analog section, that is, IC3, IC4, IC5 and all the surrounding components.

We realise that you would need to

. . . continued on page 111

Notes & Errata

6-Digit GPS Clock, May-June 2009: with some PIC16F877A chips, the local time offset and other data stored in the EEPROM could become corrupted during power down. As a result the clock would not come up with the correct local time when it was powered up again.

Merv Thomas VK6BMT Ben Rampling VK6IC discovered that this was due to a hitherto undiscovered bug in the firmware: the brown-out detector inside the 16F877A was not being enabled. Once the configuration bit BODEN was set, the problem no longer appeared.

The firmware has therefore been revised accordingly, and the latest version ('V5') will be available very soon on the Silicon Chip website (0410509E).

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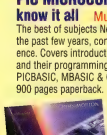

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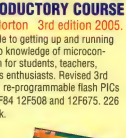

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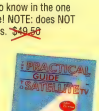

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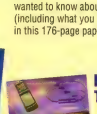

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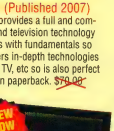

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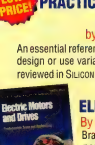

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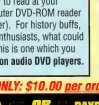

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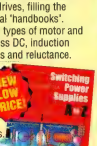

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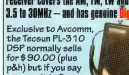

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Publisher's Letter — continued from page 2

that even though you pay for all of your energy, you only use around 70% of it. This un-used, non-productive energy wastes money and also shortens the life of inductive equipment such as motors, HVAC equipment, pumps, and major appliances".

The energy retailers would rightly be peeved at this because firstly, the claims are rubbish and second, they are conscientious in ensuring that the harmonic content of the mains waveform is kept below defined limits. Nor can the installation of capacitors do anything to clean up the mains waveform.

Thirdly, the energy retailers might also be very concerned with the concept of installing large capacitors across the consumer mains supply. Such capacitors could cause undue loading on their tone signalling systems. In fact, I would not be surprised that if they found it was a problem, they would immediately disconnect the offending premises until said capacitors were removed at the owners' expense.

As I said on the *Today Tonight* segment, "There are no easy ways to save power". If there were, we would be doing it.

Leo Simpson

Ask SILICON CHIP — continued from page 107

remove the main board from the case to do the latter but I think it's best to rule out these joints as possible problems before doing anything like removing the radio module shield.

Editor's note: feedback from the reader has confirmed that the fault was in the pins on the Venice 7 module.

Confusion between Dolby Digital and DTS

Recently, I dusted off my Denon DVD 3300 player and connected it to my hifi system and tried to play DTS and Dolby Digital at the same time. I noticed that on the disc menus it has them separate. I was hoping to have both DTS and Dolby Digital on the player's display at the same time but this doesn't seem possible. Why?

The Denon DVD 3300 player was reviewed as a player for the audiophile and it was very pricey at the time I bought it. It is still much better than most medium-priced players of today.

With the Denon player, Dolby Digital sounds much better than DTS; more hifi. Is it possible to purchase a DVD these days so that DTS and Dolby Digital can be played at the same time or is Dolby Digital separate for those who don't have DTS? (D. S., via email).

- DTS (formerly Digital Theater Systems) and Dolby Digital are two competing and incompatible surround sound systems. It is not possible to have both systems operating simultaneously, even if a DVD was encoded with both systems. There's a lot more information on this topic on Wikipedia.

iPod feed for 12V amplifier

I run a 12V bus in my house and am interested in the 12V Stereo Amplifier described in May 2010. Would it be possible to adapt the project so that it would accept an input from an iPod or equivalent? Modern car radios have such a facility as a Line input. (I. C., Longwood East, Vic).

- To connect an iPod to the 12V Stereo Amplifier you need a cable with a stereo 3.5mm phono plug on one end and two RCA plugs on the other. You also need a 10kΩ resistor to ground for each channel, to provide a DC load.

The phono plug goes into your iPod's headphone output, while the RCA plugs go into the corresponding input sockets on the amplifier. SC

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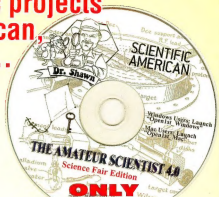

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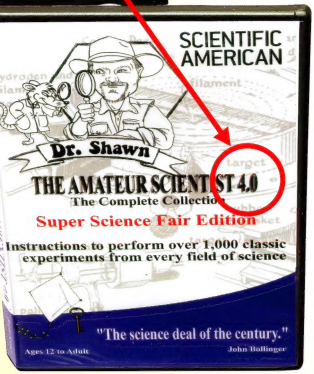

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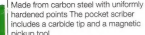

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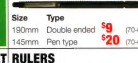

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